AQUIFER EXEMPTION REQUEST

Great River Energy
Coal Creek Station

REPORT

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EXECUTIVE SUMMARY

Coal Creek Station, owned and operated by Great River Energy (GRE), is a 1,100-megawatt coal-fired electric generation facility in McLean County, North Dakota. Coal Creek Station is a zero-liquid discharge facility and, as such, does not discharge water under a National Pollutant Discharge Elimination System (NPDES) permit. Instead, the plant manages its water inventory through the use of four on-site evaporation ponds. Due to plant environmental control improvements and wetter-than-normal climate conditions, the evaporation ponds have filled to design capacity over the last few years. To better manage process water, GRE has submitted an application to the North Dakota Department of Health (NDDH) to install one Class I non-hazardous injection well onsite. The permit application was submitted in May 2012 and is being reviewed by NDDH.

The permit application identifies a "preferred" injection interval, the Inyan Kara Formation, which holds the Dakota aquifer. The total dissolved solids (TDS) concentration of the Dakota aquifer is unknown at the proposed injection site; however, both GRE and NDDH consider it probable that it is less than 10,000 mg/L, which would result in the classification of the aquifer as a potential underground source of drinking water (USDW). Therefore, GRE is submitting this application for an aquifer exemption for the Dakota aquifer within Coal Creek Station's property boundaries.

An aquifer exemption for the Dakota aquifer already exists within Coal Creek Station's property boundaries for Class II wells. While not directly applicable to GRE's proposed Class I non-hazardous well, the Class II exemption provides support and precedent for a Class I exemption. This document requests exemption of the Dakota aquifer irrespective of the existing Class II exemption as the aquifer can be shown to meet the criteria required for exemption in federal and state regulations.

The Dakota aquifer is a regional aquifer. It is contained within the Dakota sandstone, a geologic grouping of various water-bearing sandstones and interbedded shales. At the proposed injection site, the Dakota aquifer is estimated to be located at a depth of approximately 3,550 feet to 3,900 feet below ground surface (bgs), resulting in a thickness of approximately 350 feet. The Dakota aquifer is separated from the nearest USDW in McLean County, the Fox Hills Formation, by a 2,500-foot-thick confining unit composed of the Pierre shale and other shaley formations. The water chemistry of the Dakota aquifer at Coal Creek Station is poorly defined due to a lack of data near the site, although available data suggests that the TDS concentration is likely between 5,000 and 7,000 mg/L.

The Dakota aquifer does not currently serve as a source of drinking water near Coal Creek Station or in McLean County. A survey of wells was completed within the area of exemption and a surrounding ¼ mile buffer zone, as well as within McLean County. The survey found no wells of any type that penetrated the Dakota aquifer. The Dakota aquifer is commonly used to supply both public and private water systems in eastern North Dakota, where the aquifer is shallower and much more accessible; however, the closest Dakota aquifer water supply well to Coal Creek Station is approximately 60 miles northeast of the site.

The Dakota aquifer is economically impractical as a future source of drinking water in McLean County. Local consumers have more accessible water supplies, primarily the Missouri River and Lake Sakakawea (both surface water sources), in addition to shallow glacial aquifers. Included is an economic evaluation that suggests that using Dakota aquifer water as the drinking water supply for the nearby towns of Washburn or Underwood would be more costly than current water sources. Population projections for several municipalities in McLean County suggest that, despite recent energy activity in the western part of North Dakota, McLean County's population will remain fairly constant. Therefore, it is not expected that there will be a need to extract drinking water from the deep, more saline Dakota aquifer.

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1.0 INTRODUCTION

1.1 Background

1.1.1 Great River Energy's Coal Creek Station

Coal Creek Station is a 1,100-megawatt coal-fired electric generation facility owned and operated by Great River Energy (GRE). The plant is located approximately six miles south of the city of Underwood in McLean County, North Dakota (Figure 1-1). The main plant area occupies five sections of land (8, 9, 15, 16, 17) in Township 145 North, Range 82 West, and portions of additional nearby sections (Figure 1-2). Landownership in the vicinity of Coal Creek Station is shown on Figure 1-3.

Plant operations began in the late 1970s. Four on-site evaporation ponds, designated as Evaporation Pond 91 to 94, are used to manage the overall water inventory at Coal Creek Station, which operates as a zero liquid discharge (ZLD) facility. As a ZLD facility, Coal Creek Station is not permitted to discharge water under a National Pollutant Discharge Elimination System (NPDES) permit. The evaporation ponds at Coal Creek Station provide water storage capacity for the plant and remove excess water inventory through evaporation.

Over the last few years, the evaporation ponds have filled to design capacity due to plant environmental control improvements (e.g., scrubber modifications) and wetter-than-normal climate conditions. GRE began implementing strategies to manage the increase in excess water inventory, which include higher operating elevations for ponds, operational changes, mechanical evaporators, and pond liner extensions.

1.1.2 Underground Injection Project

1.1.2.1 2012 Underground Injection Permit Application

To provide additional flexibility and capacity for plant water management, GRE submitted a permit application to the North Dakota Department of Health (NDDH) in 2012 to install one Class I non-hazardous injection well onsite (Golder Associates Inc., 2012). For maximum flexibility during well construction, and given the uncertainty of the geologic conditions at Coal Creek Station, the permit application identified two potential injection alternatives: a preferred injection interval (the Inyan Kara Formation) and an alternative injection interval (the Minnelusa Formation). Given its more favorable properties for injection, the well would be completed in the preferred injection interval unless its water quality defined it as an underground source of drinking water (USDW), in which case the alternative injection interval would be used. This multiple alternative approach, however, proved challenging from a permitting and construction standpoint, so GRE made the decision to pursue an aquifer exemption for the preferred injection interval.

The permit application contains a significant amount of information that can be referenced for details on the proposed underground injection well, including hydrogeology, flow and transport modeling, geochemistry, and well design. This document summarizes some of that information as it relates to an aquifer exemption request.

1.1.2.2 Definition of Aquifer to be Exempted

The aquifer to be exempted will be referred to in this document as the "Dakota aquifer," which generally consists of various sandstone and shale layers of Cretaceous age. While various terms may be used to describe this geologic unit, including the Lower Cretaceous aquifer, Inyan Kara Group, Fall River Formation, Fuson Formation, and Lakota Formation, it is generally acceptable to simply reference the Dakota aquifer. The 2012 permit application uses the term "Inyan Kara Formation" to define the preferred injection interval because that document is principally concerned with the rock formation as opposed to the aquifer.

1.1.2.3 Description of Proposed Injectate

One Class I injection well is proposed for injection of non-hazardous plant process water into the subsurface. The injection fluid will be water from the Drains Pond, which consists of cooling tower blowdown and other process waters. Historical chemistry of the proposed injectate is included in Table 1-1. These fluids will be pumped from the Drains Pond into the proposed injection well at a maximum rate of 500 gallons per minute (gpm). The proposed injection well will be located on a well pad just north of the Drains Pond on GRE property (Figure 1-2) and GRE will own and operate the well.

1.2 Existing Class II Aquifer Exemption

1.2.1 Existing Exemption for Class II Injection into the Dakota Aquifer

In February 1983, the North Dakota Industrial Commission (NDIC) applied for and was granted an exemption for the Dakota aquifer for Class II injection in the western part of North Dakota (Olson and Jones, 1983). This exemption is defined by a collection of townships and ranges, which includes Coal Creek Station (Figure 1-4).

The Class II exemption was approved based on four arguments:

1. The Dakota aquifer did not serve as a source of drinking water in the proposed exempted area;
2. The depth of Dakota aquifer in the proposed exempted area (2,000 feet – 5,000 feet below ground surface) was such that recovery of water to supply a public water system would have been economically impractical;
3. The quality of water in the Dakota aquifer in the proposed exempted area (4,000 – 10,000 mg/L) was such that treatment of the water for human consumption would have been economically impractical; and

4. That in the exempted area, the higher quality and shallower Tertiary and Upper Cretaceous aquifers would be capable of supplying sufficient water for public consumption.

Table 1-2 lists the Class II saltwater disposal wells currently permitted to inject into the Dakota aquifer (also described as the Inyan Kara formation). Figure 1-5 shows the spatial distribution of these wells.

1.2.2 Chemical Characteristics of Class II Injectate

Table 1-2 provides general information about several Class II saltwater disposal wells permitted to inject into the Dakota aquifer in North Dakota. In addition, measurements of total dissolved solids (TDS) for permitted injectate are included. The TDS values of the injectate in this sample set range from approximately 11,000 mg/L to 425,000 mg/L, although most fall between 150,000 mg/L and 300,000 mg/L. The likely TDS of GRE's injectate, based on the historical data shown in Table 1-1, is between 9,500 mg/L and 21,000 mg/L, or approximately 10% of the TDS observed in oil and gas (Class II) injectate.

The average TDS concentration of Class II injectate in North Dakota, as seen in Table 1-2, is much higher than that of waters found in the Dakota aquifer. In addition, concentrations of certain constituents in oil field wastewater often exceed the EPA's primary (barium and chromium) and secondary (chloride, sulfate, and TDS) drinking water standards (North Dakota Industrial Commission, 2012; US EPA, 2012).

1.2.3 Relevance of Class II Exemption

The existing exemption of the Dakota aquifer is for Class II wells, so it is not directly applicable to GRE's proposed Class I non-hazardous well. This document requests exemption of the Dakota aquifer irrespective of the existing Class II exemption as the aquifer can be shown to meet the criteria required for exemption in the federal and state regulations. It is relevant, however, to consider the existing Class II exemption as it relates to this aquifer exemption request. The Class II exemption area includes Coal Creek Station, which establishes a precedent for the exemption of the Dakota aquifer in that area. Additionally, the TDS of the Class II injectate is an order-of-magnitude greater than both the aquifer's TDS and GRE's proposed injectate. For these reasons, the Class II exemption provides additional support for a Class I exemption.

1.3 Summary of Regulations

GRE's 2012 underground injection permit application followed the relevant North Dakota and federal regulations for construction of a Class I non-hazardous injection well. To manage the uncertainty associated with the water quality of the Dakota aquifer (see Section 2.1.3), GRE is requesting exemption of the aquifer from protection as a USDW. Regulations NDAC 33-25-01 and 40 CFR 146.3 define a USDW as any aquifer (or portion thereof) that:

(a) Supplies any public water system; or

(b) Contains a sufficient quantity of ground water to supply a public water system and:

  (1) Currently supplies drinking water for human consumption; or

  (2) Contains fewer than ten thousand milligrams per liter total dissolved solids; and

  (3) Is not an exempted aquifer.

As described in 40 CFR 146.4 and NDAC 33-25-01-05, an aquifer that meets the criteria of a USDW may be exempted if it meets the following criteria (quoted from 40 CFR 146.4):

(a) It does not currently serve as a source of drinking water; and

(b) It cannot now and will not in the future serve as a source of drinking water because:

  (1) It is mineral, hydrocarbon or geothermal energy producing, or can be demonstrated by a permit applicant as part of a permit application for a Class II or III operation to contain minerals or hydrocarbons that considering their quantity and location are expected to be commercially producible.

  (2) It is situated at a depth or location which makes recovery of water for drinking water purposes economically or technologically impractical;

  (3) It is so contaminated that it would be economically or technologically impractical to render that water fit for human consumption; or

  (4) It is located over a Class III well mining area subject to subsidence or catastrophic collapse; or

(c) The total dissolved solids content of the ground water is more than 3,000 and less than 10,000 mg/l and it is not reasonably expected to supply a public water system.

Additional information on the criteria for evaluating aquifer exemption requests is provided in EPA's GWPB Guidance 34 (Kimm, 1985), which describes general information requirements and specific criteria for each type of exemption request. This aquifer exemption request has been prepared following the regulations described above and the criteria described in Guidance 34.

2.0 GENERAL CRITERIA

2.1 Description of Aquifer to be Exempted

The following section provides a general description of the aquifer to be exempted, the Dakota aquifer. This text is intended to address the requirements outlined in the subsection of EPA's GWPB Guidance 34, Attachment 3, entitled "Evaluation Criteria – General" (Kimm, 1985).

2.1.1 Geologic Properties of the Aquifer to be Exempted

2.1.1.1 Regional Geologic Structure

Coal Creek Station is located within the Williston Basin, which has a stratigraphic structure as conceptualized in Figures 2-1 (Downey, 1986) and 2-2. The basin is bounded to the west by the Bighorn Mountains in Wyoming and Montana, and to the east by the Red River of the North, which forms the border between North Dakota and Minnesota. In general, surface topography in North Dakota gradually slopes from west to east. Stratigraphic layers ranging in age from the Upper Cretaceous to the Cambrian-Ordovician dip east from the Bighorn Mountains towards the center of the basin, reaching a low point under Dunn County, North Dakota. From the low point, the layers begin to rise (dip west) as they move east, pinching out or surfacing just west of the Red River of the North. In general, deeper formations in the basin dip more steeply than the shallower formations. Figure 2-3 (Waldkirch, 2000) shows the stratigraphic structure of North Dakota.

2.1.1.2 Local Geologic Structure

The local geologic stratigraphy and structure was evaluated using data from oil and gas wells (NDIC, 2012) within approximately 30 miles of the proposed injection site. Top-of-formation depths were entered into RockWorks2004, and that software was used to create a model of the local geologic structure (Golder, 2012). Table 2-1 summarizes the estimated depths of principal geologic horizons at the proposed injection site.

2.1.1.3 Structure of Aquifer to be Exempted

The aquifer to be exempted is the Dakota aquifer. The geologic unit that includes the aquifer, the Dakota Group, is a well-developed Cretaceous-age sandstone unit (Bluemle, 1971), and is expected to have relatively high permeability and be receptive to underground injection. At the proposed injection site, the Dakota aquifer is estimated to be located at a depth of approximately 3,550 feet to 3,900 feet below ground surface (bgs), resulting in a thickness of approximately 350 feet. The actual extents of the aquifer will be determined upon drilling.

2.1.2 Vertical Confinement of the Aquifer to be Exempted

A low-permeability confining unit separating the aquifer from the lowest USDW is important for safe underground injection. The confining unit should retard vertical migration of any injectate into drinking water sources. This sub-section identifies the lowest USDW at the proposed injection site as well as the confining unit that separates the two aquifers.

2.1.2.1 Lowest Underground Source of Drinking Water at the Proposed Injection Site

Based on existing water wells in McLean County, the Fox Hills Formation, the lowermost unit of the Upper Cretaceous aquifers (Whitehead, 1996), was determined to be the lowest local underground source of drinking water. The Fox Hills Formation overlies the Pierre shale (Figure 2-3). The log from one domestic well in McLean County, located 25 miles northeast of the proposed injection site, lists the depth to the top of the Fox Hills Formation as 681 feet bgs. Geologic logs from nearby abandoned oil and gas wells suggest that the base of the formation is approximately 1,000 feet bgs. The formation is between 233- and 450-feet thick, based on information obtained from drillers' logs for registered water wells. In addition to the water quality data included in Section 2.3.2, water quality samples collected from six USGS monitoring wells in McLean County indicate TDS values ranging from 1,430 to 1,630 mg/L (United States Geological Survey, 2012).

2.1.2.2 Vertical Confining Unit

The Fox Hills Formation is isolated from the Dakota aquifer by the shaley Cretaceous confining unit, composed of the Pierre, Niobrara, Carlile, Greenhorn, Belle Fourche, and Mowry Formations (listed in descending order). This grouped unit is estimated to be 2,475 feet thick near the proposed injection site. The predominant formation in the Cretaceous confining unit is the Pierre shale. The Pierre shale is an areally extensive layer that can exceed 3,000 feet of thickness in some sections of the northern Great Plains. Subsequent units, although not as thick, do act as effective confining units, particularly as part of the larger group of formations comprising the Cretaceous confining unit (Downey and Dinwiddie, 1988). Previous aquifer studies, most notably the United States Geological Survey (USGS) Regional Aquifer Systems Analysis (RASA) and the USGS Hydrologic Investigations Atlas, have grouped these units together as the uppermost bedrock confining unit in the Williston Basin region (Downey and Dinwiddie, 1988; Whitehead, 1996).

2.1.3 Water Quality in the Aquifer to be Exempted

The water quality of the Dakota aquifer is very poorly defined near the proposed injection site due to a lack of available data. Figure 2-4 shows the available data, but extrapolating this data to the injection site results in a wide range of potential water quality. Data from oil and gas well drilling files (NDIC, 2012) suggest that the TDS is likely between 5,000 and 7,000 mg/L, but may be less than 3,000 or more than 10,000 mg/L. As part of GRE's underground injection permit application (Golder, 2012), a mass balance mix of chemistries measured at several wells nearest to Coal Creek Station was used to calculate a probable aquifer TDS value at the site of 6,369 mg/L. Water quality data used to estimate this value, as well as construct a geochemical compatibility model for the aquifer under injection conditions, is shown in Table 2-2 with additional information provided in the permit application.

2.2 Proposed Area of Exemption

2.2.1 Proposed Area of Aquifer Exemption

The chosen boundary of the proposed area of aquifer exemption is a portion GRE's Coal Creek Station property boundary (Figure 2-5), an area of approximately 6.1 square miles or 3,900 acres. The chosen area includes the primary plant area and property in Section 5, but not additional GRE property.

2.2.2 Support for Proposed Area of Aquifer Exemption – Results of Groundwater Modeling

A groundwater flow and transport model simulating injection at Coal Creek Station into the Dakota aquifer was constructed and run as part of GRE's underground injection permit application (Golder, 2012). The software used to build the model was AquiferWin32, an interactive, analytic element modeling tool that simulates two-dimensional (in the horizontal plane) steady-state and transient groundwater flow. The model is further described in the permit application, and model input parameters and results, based on the best available data for the well design and the target formation, are summarized in Appendix A.

Particle tracing was used to estimate the distance that a particular constituent injected into the Dakota aquifer would travel during 50 years of continuous injection at 500 gpm (Figure 2-6). A conservative estimate is that these chemical constituents will travel at the same velocity as water particles. Under these conditions, the most mobile constituents are expected to travel down-gradient no more than one-half mile, meaning that they will not have left the confines of GRE's property boundary or the proposed area of aquifer exemption.

3.0 SUPPORT FOR CFR 146.4(A) – THE DAKOTA AQUIFER DOES NOT CURRENTLY SERVE AS A SOURCE OF DRINKING WATER NEAR COAL CREEK STATION

3.1 Water Wells in McLean County

Much of the drinking water supply in McLean County comes from surface water sources, primarily the nearby Missouri River and Lake Sakakawea (see Section 4.1). However, groundwater is used as a (chiefly domestic) source of drinking water in the county. Figure 3-1 shows the documented water wells (including domestic, municipal, irrigation and industrial wells) in McLean County (North Dakota State Water Commission, 2012). Table 3-1 lists information for each well shown in the figure, including, if available, the total depth of the well and the lowest formation into which it penetrates.

Figure 3-2 shows a more detailed survey of water wells within the proposed area of exemption as well as a ¼ mile "buffer zone" surrounding the proposed exemption area. The width of the buffer zone was chosen based on the recommendation included in the "Evaluation Criteria – General" section of EPA's GWPB Guidance 34, Attachment 3 (Kimm, 1985). Table 3-2 lists the wells shown in this Figure 3-2.

Tables 3-1 and 3-2, along with Figures 3-1 and 3-2, show that no water wells near Coal Creek Station penetrate deeper than the Fox Hills Formation. This data demonstrates that the Dakota aquifer does not currently serve as a source of drinking water near Coal Creek Station.

3.2 Use of the Dakota Aquifer as a Drinking Water Source

While not used as a source of drinking water near Coal Creek Station, the Dakota aquifer is the primary source of water for livestock watering and domestic supply in eastern North Dakota. The Dakota aquifer is the shallowest consolidated-rock aquifer in eastern North Dakota. Groundwater in the Dakota aquifer flows regionally northeastward from recharge areas in central Montana and northeast Wyoming to discharge areas in eastern North Dakota and South Dakota near the Red River of the North (Figure 3-3), which forms the eastern boundary of the state of North Dakota. The shallower bedrock aquifers present in the western and middle portions of the state, including the Fox Hills Formation, pinch out in Wells County.

Figure 3-4 shows the water supply wells in North Dakota that pull from the Dakota aquifer. The nearest down-gradient well to the proposed injection site is a domestic well in Wells County, located approximately 60 miles from Coal Creek Station.

4.0 SUPPORT FOR CFR 146.4(B)(2) – THE DAKOTA AQUIFER IS SITUATED AT A DEPTH OR LOCATION WHICH MAKES RECOVERY OF WATER FOR DRINKING WATER PURPOSES ECONOMICALLY OR TECHNOLOGICALLY IMPRACTICAL

As demonstrated in the Section 3.0, the Dakota aquifer is not currently used as a source of drinking water near the proposed injection site or in McLean County. The likely reasons the Dakota aquifer has not been developed as a water supply source closer to the proposed injection site include:

1. The presence of several higher-quality groundwater and surface water supplies that are more easily accessible;
2. Greater depth than is practical to drill for a municipal or domestic water well; and
3. High salinity/low quality, necessitating significant investments for treatment.

These factors also explain why the Dakota aquifer is unlikely to be used in the future as a source of drinking water for McLean County residents. Current surface and underground sources of drinking water in McLean County are more easily accessible and of better quality than the Dakota aquifer. In addition, drilling to the Dakota aquifer and/or treating water from that aquifer would likely be very expensive for a small community. This section of the aquifer exemption request will discuss the above three points in further detail and demonstrate that the Dakota aquifer is impractical for use as a future source of drinking water in McLean County.

4.1 Water Supply Sources in McLean County

4.1.1 Lake Sakakawea – the Primary Drinking Water Source in McLean County

Lake Sakakawea is a large man-made reservoir along the Missouri River. It is the third-largest man-made lake in the United States and was created in 1953 when the Garrison Dam was constructed. The reservoir is approximately 178 miles long, and is 6 miles across at its widest point. The reservoir covers 380,000 acres and holds, when full, 23.8 million acre-feet of water, or "approximately one-third of the total storage capacity of the Missouri River reservoir system" (U.S. Army Corps of Engineers, Omaha District, 2011). Whether their intake structures are located within the bounds of the reservoir or just downstream, most municipal water systems in McLean and other nearby counties are supplied by Lake Sakakawea. Statistics compiled by the North Dakota State Water Commission (NDSWC) from 1989 to 2009 indicated that in the greater Lake Sakakawea area (which includes 11 counties near or bordering the reservoir), approximately 80% of the water consumed by the population is derived from surface water sources, while only 20% is supplied by groundwater. The disparity is even more exaggerated in McLean County where, on average, 14,901 of the 17,407 acre-feet (86%) consumed annually was from surface water sources; only 2,506 acre-feet, or 14%, was groundwater.

4.1.2 Groundwater Sources in McLean County

Glacial deposits of Quaternary age comprise the youngest water-bearing formations in McLean County and overlie local bedrock aquifers. The shallow aquifers (each of which often underlies only a small section of the county) held in these deposits have the highest potential for development of all aquifers used in the county. Many local depositional aquifers are combined into a county-wide aquifer system; the most well-known and commonly-used system in McLean County is the Lake Nettie Aquifer System, which is comprised of the Lake Nettie, Strawberry Lake, Turtle Lake, and Horseshoe Valley aquifers. Other local glacial aquifers include the White Shield, Lost Lake, Snake Creek, Weller Slough, Wolf Creek, and Garrison aquifers, among others. Water in the glacial aquifers is typically hard to very hard. TDS values range from 200 to 3,000 mg/L. Glacial aquifers supply industrial, rural water, stock, domestic, irrigation, and municipal water wells in McLean County (Klausing, 1974).

Bedrock aquifers in McLean County include the Lower Tertiary (Fort Union) and Upper Cretaceous (Hell Creek/Fox Hills) aquifers. Figure 4-1 shows the extents of those aquifers within North Dakota. The Fort Union Group is the oldest Tertiary group in both McLean County and in North Dakota. It is situated beneath the glacial deposits discussed above, and consists of interbedded and typically discontinuous silt, siltstone, clay, shale, sandstone, and lignite beds, which are typically discontinuous. Although the Fort Union Group is mostly covered by glacial deposits, some outcrops are present in McLean County. The thickness of the Fort Union Group ranges from 127 feet in eastern McLean County to 1,100 feet to the west. Sandstone beds, the predominant source of water within the group, range in thickness from a few feet to 225 feet. Water in the Fort Union Group is hard or very hard. TDS values in the Fort Union are between 206 and 3,550 mg/L (based on 65 samples). In areas of thick sandstone, yield can be as high as 200 gpm. The Fort Union supplies stock, domestic, and municipal wells in McLean County (Klausing, 1974).

The Hell Creek Formation, Cretaceous in age, underlies the Fort Union Group in McLean County. It consists of interbedded silty shale and sandstone. One well log in eastern McLean County recorded a depth to the top of the Hell Creek Formation of 320 feet bgs, and a thickness of 220 feet; however, such data is sparse in the western part of the county. Water in this aquifer, like in the Fox Hills Formation, is soft. TDS values in the Hell Creek range from 1,200 and 1,630 mg/L (based on five samples). Yields of up to 50 gpm have been reported. In McLean County, the Hell Creek Formation is primarily used to supply stock and domestic wells (Klausing, 1974).

The oldest formation containing a water supply aquifer in McLean County is the Upper Cretaceous Fox Hills Formation. The Fox Hills Formation conformably underlies the Hell Creek formation, and overlies the Pierre shale. It consists of interbedded mudstone, siltstone, and sandstone layers. The Fox Hills Formation ranges in depth from 540 feet bgs in the eastern part of McLean County to 1,200 feet bgs in the western part of the county. The formation is between 233- and 450-feet thick, based on information obtained from drillers' logs for registered water wells. The aquifer is under artesian pressure and has a potentiometric gradient that decreases to the east. Water supplied by the Fox Hills Formation is soft. TDS concentrations in the aquifer range from 1,370 to 1,550 mg/L (based on six samples). Although the potential yield of the aquifer in McLean County has not explicitly been measured, well yields of 10 gpm are typical. In McLean County, the Fox Hills Formation primarily supplies domestic and municipal wells (Klausing, 1974).

The Tertiary and Upper Cretaceous aquifers in North Dakota, while separated in places by local confining units, are for the most part regionally linked. Groundwater in the Lower Tertiary aquifer generally flows northeast from recharge areas in eastern Montana, northeastern Wyoming, and southwestern North Dakota. Regional groundwater flow patterns in the Upper Cretaceous aquifer closely resemble those of the overlying Lower Tertiary aquifer, with flow northeast from recharge areas in eastern Montana and northeastern Wyoming and to discharge zones in the Missouri River and its tributaries. The potentiometric surface of this aquifer generally parallels the surface topography due to its regionally unconfined condition. Large surface water bodies in the region, including the Missouri River and, by extension, Lake Sakakawea, are discharge areas for the Lower Tertiary aquifer, resulting in potentiometric contours that follow the course of the rivers. Due to its hydraulic connection with these aquifers, the water level in Lake Sakakawea greatly affects the potentiometric surface in the lower Tertiary and Upper Cretaceous aquifers, particularly near the lake itself. Since McLean County borders the river, the local potentiometric heads of the Fort Union Group and Hell Creek and Fox Hills aquifers are in close connection to water levels in Lake Sakakawea (Whitehead, 1996).

4.2 Dakota Aquifer TDS as Compared to the TDS of the Fox Hills and Other Local Drinking Water Sources

The estimated TDS of water in the Dakota aquifer at the proposed injection site (5,000 – 7,000 mg/L) is greater than TDS concentrations in measured water samples taken from the Fox Hills Formation. As reported by Klausing (1974) in his report on the groundwater resources of McLean County, TDS concentrations in the Fox Hills ranges from 1,370 to 1,550 mg/L (based on six samples). TDS concentrations measured locally in shallower aquifers are also lower than the predicted concentration in Dakota waters; measured TDS values in the Hell Creek Formation, Fort Union Group, and the glacial aquifers ranged from 1,200 to 1,630 mg/L (five samples), 206 to 3,550 mg/L (65 samples), and 200 to 3,000 mg/L (number of samples unknown), respectively.

The TDS concentration of Lake Sakakawea is generally lower than the TDS values measured in local groundwater sources. From June 1993 to September 2011, the TDS of Lake Sakakawea water samples collected at Riverdale, ND ranged from 364 to 480 mg/L. At Hazen Bay, near Garrison, ND, TDS ranged from 341 to 476 mg/L over the same time period (North Dakota Department of Health, 2012). These measurements demonstrate that TDS concentrations in Lake Sakakawea, the primary source of drinking water in the area near Coal Creek Station, are consistent and low.

The TDS concentrations of surface and underground water resources used for drinking water near the proposed injection site are lower than the concentration predicted for the Dakota aquifer in that area. The greater depth to the Dakota aquifer than the Fox Hills Formation, Hell Creek Formation, Fort Union Group, and the glacial aquifers, as well as the poor predicted quality of the water contained in the formation, make it economically impractical to attempt to supply a public water supply system near Coal Creek System with water from the Dakota aquifer. Therefore, if no great stress were placed upon the current water supply system, it is unlikely that the Dakota aquifer would be considered as a drinking water source in McLean County and other nearby counties.

4.3 Adequacy of Current Water Supply Sources to Supply Future Needs

4.3.1 Population Projections

Before the recent boom in oil and gas extraction from the Bakken shale formation, which began in late 2008, many population studies predicted that the population of rural North Dakota would, as it had done historically, continue to gradually shrink. However, more recent studies have attempted to project the population of both urban and rural communities in a way that accounts for energy industry growth in western North Dakota.

4.3.1.1 Historical Population of McLean County

McLean County is a predominantly rural county in west-central North Dakota. As of the 2010 US Census, the county population was 9,068. In North Dakota, since the 1940s, rural population has declined from 80% to 46% (Center for Social Research, North Dakota State University, 2012). Historical populations and growth percentages of in McLean County from 1960 through 2010 are shown in Table 4-1, below.

Table 4-1: Population Totals and Growth Percentages for McLean County Since 1960

Year	Population	Growth Percentage from Past Census (%/10 years)
1960	14,030	--
1970	11,251	-19.8%
1980	12,383	+10.1%
1990	10,457	-15.6%
2000	9,311	-11.0%
2010	8,962	-3.7%

Source: U.S. Census Bureau (U.S. Census Bureau, 2012; Forstall, 1995)

From 1940 to 2000, North Dakota's population has remained relatively stable, growing from 641,935 to 642,200, a growth of 0.04% over 60 years. However, due in large part to the energy development in the western part of the state, the state's population increased 5% from 2000 to 2010, reaching 672,591 residents at the end of the decade. However, this growth was largely regional, not state-wide. A U.S. Census Bureau estimate of North Dakota population change from 2008 to 2009 (the first year of the oil boom) found that western counties, such as Williams and Mountrail, and Burleigh and Cass Counties (both of which contain urban centers) grew between 1.2% and 3.6% in that year alone. However, many other counties, including McLean County, experienced no growth or even a slight decrease in population. As can be seen in Table 4-1 above, McLean County experienced a decline during the most recent decade (2000 to 2010). These figures do not take into account the seasonal rise in population that occurs in the county in the summer due to vacation homes on Lake Sakakawea; however, this rise is likely minor compared to the permanent population trends described above.

Development of the Parshall oil field in western McLean County has the potential to alter future population change patterns, potentially leading to growth in a county that has experienced an overall decline in population for the last 50 years. However, such changes are most likely to occur in urban centers in the western part of the county, not in the eastern portion where Coal Creek Station is located. Vision West North Dakota has developed population projections for three cities in east-central McLean County that address future changes in population and required infrastructure updates, including projected increases in water system supply. These projections are discussed in detail in the following section.

4.3.1.2 Population Projections and Expected Water Demand for Cities in McLean County

Garrison is the largest city in McLean County. As reported in the Vision West North Dakota (Advanced Engineering and Environmental Services, Inc. (AE2S), 2012a) study, the city of Garrison had a population of 1,318 at the time of the 2010 U.S. Census. The estimated current population of the city is 1,430, and the projected population in 2015 is 1,600, a substantial growth of 12% over three years. The City of Garrison uses water from Lake Sakakawea, a Missouri River reservoir on the border of McLean and Mercer Counties. The city's water treatment plant, which has a capacity of one million gallons per day (gpd), supplies both the Garrison Rural Water Association (GRWA) as well as the city itself. In 2005, two new raw water intake pumps with a combined capacity of 450 to 750 gpm were installed to increase the city's raw water intake capacity. The city's arrangement with the GRWA allows for the sale of up to 20% of the treatment plant capacity, or 200,000 gpd, which is sufficient to meet the peak daily demand of the GRWA's members. The estimated maximum daily demand of the city in 2015, based on the projected population of 1,600, is 480,000 gpd. The Garrison water treatment plant's capacity is sufficient to provide the 480,000 gpd needed by the city and the maximum 200,000 gpd sold to the GRWA. Based on the projected demands for both the city and the GRWA, the net maximum daily pumping rate required would be 473 gpm, below the capacity of the intake pumps as well as the permitted withdrawal rate from Lake Sakakawea (650 gpm) (NDSWC, 2011).

The City of Garrison does maintain one groundwater well (capacity 350 gpm) for emergencies; however, the projected future demand should be easily met by the existing infrastructure, and the well will likely continue to be operated as an emergency supply only. The current infrastructure and water supply at Garrison is sufficient to meet the projected future demands, and no upgrades to the system are recommended (Advanced Engineering and Environmental Services, Inc. (AE2S), 2012a).

Washburn, the county seat of McLean County, had a population of 1,246 in 2010 (U.S. Census Bureau, 2010). The City of Washburn, like Garrison, obtains the water needed for its public supply from the Missouri River. The Washburn water treatment plant is relatively new, having been completed in 2010, and has a capacity of 1,200 gpm, allowing it to meet the current and expected future needs of its customers (City of Washburn, 2012).

The population of the City of Underwood was 778 in 2010 (U.S. Census Bureau, 2012), and is currently estimated by city officials to be approximately 860. This represents a modest growth rate of 5% over the past two years. Assuming an annual growth rate of 5% over the next five years, the projected population of Underwood in 2017 is 1,100. The estimated maximum daily water demand in 2017, based on a population of 1,100, is 312,676 gpd. The City of Underwood has five municipal wells for water supply. However, due to poor groundwater quality, the wells are not currently in use; instead, the city has chosen to purchase water from the nearby city of Riverdale. Riverdale pumps its water from Lake Sakakawea. The contract allows for the purchase of up to 743,000 gpd, which is far in excess of the projected maximum daily demand in 2017. Therefore, it is probable that the current contract between Riverdale and Underwood will be able to accommodate the growing demand for water in Underwood (AE2S, 2012b).

Turtle Lake, North Dakota is a smaller community than Garrison, Washburn, or Underwood; however, it exemplifies the current and future demands of a large rural community. As of the 2010 U.S. Census, Turtle Lake had a population of 581; today, the population is estimated to be 610. The projected population in five years (2017) is 708, assuming a population growth rate of 2.5% per year. The estimated future maximum daily demand is estimated to be 169,000 gpd. The city has a contract in place with the McLean-Sheridan Joint Water Resource Board, which extracts water from the glacial Lake Nettie aquifer and supplies several rural customers and smaller municipalities in McLean and Sheridan Counties. Turtle Lake's contract allows for a maximum daily delivery of 175,000 gpd, in excess of the projected maximum daily demand in 2017. Therefore, the current water supply for the City of Turtle Lake should be sufficient to supply future demand (AE2S, 2012c).

Much of McLean County, being rural, is unaccounted for in the above studies. Private wells can be problematic in McLean County due to poor water quality in the shallow aquifers. Instead, many rural communities are serviced by local water districts, including the previously-mentioned Garrison Rural

Water District and the McLean-Sheridan Joint Water Resource Board, as well as the South Central Regional Water District, the North Prairie Rural Water District, and the Fort Berthold District. It is unlikely that rural water demand will increase substantially, or at all, largely due to the previously-discussed (Section 4.3.1.1) trend in North Dakota towards urbanization, and the corresponding decrease in rural population. The largest driver of recent population increase in North Dakota has been the energy industry, which favors population increase in urban communities. Therefore, potential changes in rural water demand in McLean County are expected to be minimal.

4.4 Economic Evaluation

4.4.1 Economic Evaluation Description

GRE performed an economic evaluation to compare the costs of supplying a given municipal system with water from the Dakota aquifer below CCS (the water proposed for exemption) versus the current cost of water in that municipality. The evaluation was completed for the two towns nearest to CCS, Washburn and Underwood (Figure 1). Both towns are currently supplied by surface water (the Missouri River or Lake Sakakawea). Costs for the Dakota aquifer system were limited to supply, delivery, and treatment; distribution costs were excluded. The scope of this evaluation was to develop costs for comparison purposes; this evaluation is not intended to estimate budgetary detailed costs for a full water supply system.

4.4.2 Economic Evaluation Methodology

The economic evaluation included the following steps:

- Develop the design flow rate. The design flow rate, required for basic sizing of infrastructure, was selected based on historic water usage of Washburn and Underwood. Actual water demand is variable, so for simplification this evaluation used one flow rate, intended to be conservative, for each town.
- Estimate capital costs. These costs included drilling one well to the Dakota aquifer, installing a well pump and pipeline to deliver water to the town, providing power to the well pump, and constructing a water treatment facility.
- Estimate operation and maintenance (O&M) costs. These costs included power to run the well pumps and O&M costs associated with the water treatment facility.
- Estimate the cost of water for the Dakota aquifer system. A cash flow analysis was completed to estimate the cost per 1,000 gallons required for the town to recover their expenditures.
- Compare the estimated Dakota aquifer system cost with a simplified current cost of water for each town. The simplified current cost of water combined the towns' base and surplus rates into one rate using per capita water usage.

Costs were estimated using vendor and contractor quotes, data supplied by the towns of Washburn and Underwood, and Golder's engineering judgment and experience. Backup information for the economic evaluation is provided in Appendix C.

4.4.3 Economic Evaluation Results

Table 4-2 summarizes the estimated capital costs, O&M costs, and cost of water per 1,000 gallons for the Dakota aquifer system, as well as the estimated cost of water per 1,000 gallons for the current systems of both Washburn and Underwood. For Washburn, the Dakota aquifer system cost of $25.14/1,000 gallons is 170% greater than the current cost of $9.34/1,000 gallons. For Underwood, the Dakota aquifer system cost of $41.19/1,000 gallons is 510% greater than the current cost of $6.76/1,000 gallons. Since the estimated Dakota aquifer system costs exclude distribution, the actual costs of the Dakota aquifer system would be even higher.

If Washburn or Underwood were to install wells into the Dakota aquifer for drinking water supply, the wells would likely be located near those towns, rather than on GRE's property. The characteristics of the Dakota aquifer (water quality, formation depth, etc.) can be assumed to be similar between the three locations, resulting in similar costs for well construction and water treatment. The difference would be in the pipeline cost; locating the wells near the towns would save millions of dollars in pump and pipeline costs versus locating the wells on GRE's property.

The results of this economic evaluation indicate that use of the Dakota aquifer beneath GRE's property boundaries (the area proposed for exemption) for drinking water purposes is significantly greater than current water sources, making the Dakota aquifer water economically impractical.

4.5 Summary of Current and Future Water Supply in McLean County

McLean County is largely reliant on surface water for its drinking water supply. Lake Sakakawea and the Missouri River provide much of the water consumed in the county, particularly in urban areas such as Garrison and Washburn. However, groundwater is an important part of the rural water supply, through the McLean Sheridan Joint Water Resource Board, private wells, and emergency municipal supplies. These wells predominantly extract water from the shallow glacial drift aquifers, although bedrock formations such as the Fort Union Group, the Hell Creek Formation and the Fox Hills Formation are also used for water supply. The Dakota aquifer is the next shallowest aquifer after the Fox Hills. However, unlike the latter formation, the Dakota aquifer is not used and likely will not be used in the county for drinking water supply. The reasons for this include:

1. The Dakota aquifer is too deep to be an economically viable source of drinking water for communities in McLean County.
2. Water from the Dakota aquifer is much more saline than area surface water or other groundwater sources in the county, and would be difficult for a small community to treat.
3. Current population projections for McLean County, even when taking into account the recent increase in energy activity in the state, do not indicate that any additional water supply will be necessary in the near future in McLean County.

The first two reasons are evident in the results of the economic evaluation described in Section 4.4 – drilling to the Dakota aquifer and/or treating water from that aquifer would likely be too costly for a small community. The predicted depth to the Dakota aquifer near the proposed injection site, 3,550 feet, is not necessarily prohibitive; many municipalities in the Midwest, including Rapid City, SD, and Waukesha, WI, rely on groundwater from wells between 2,000 and 4,000 feet in depth. However, these cities have populations of, approximately, 68,000 and 70,000; by contrast, Garrison, the largest community in McLean County, has a population under 1,500. It is not practical for such a small community to drill a well to that depth and pipe water several miles, particularly when other supplies are readily available and significantly less expensive. Similarly, treatment of Dakota aquifer water, with its TDS of around 6,500 mg/L, would be expensive for a small municipality. Without rapid population growth, a small community has little reason to go to such a deep and saline aquifer for drinking water supply.

There is no evidence that suggests that the population of McLean County will change significantly in the near future. The county's population has been in decline since 1940, and even the North Dakota oil boom has not changed that pattern. McLean County is on the outskirts of the oil fields and, while some activity has occurred in the far western portion of the county, the central and eastern portions have been quiet. Even over the one-year span of 2008 to 2009, in which many western counties grew dramatically, McLean's growth rate stayed steady at 0%. If the current population trends continue as expected, current water supplies will easily meet the needs of future populations. Under those conditions, extraction of water from the Dakota aquifer for public water supply in McLean County will be both economically impractical and unnecessary.

5.0 SUMMARY OF AQUIFER EXEMPTION REQUEST

This aquifer exemption request proposes that the Dakota aquifer below the property boundary of GRE's Coal Creek Station be exempted from protection as an underground source of drinking water for Class I underground injection wells.

An aquifer exemption for the Dakota aquifer already exists within Coal Creek Station's property boundaries for Class II wells. While not directly applicable to GRE's proposed Class I non-hazardous well, the Class II exemption provides support and precedent for a Class I exemption. This document requests exemption of the Dakota aquifer irrespective of the existing Class II exemption as the aquifer can be shown to meet the criteria required for exemption in the federal and state regulations.

The Dakota aquifer is a geologic grouping of various water-bearing sandstones and interbedded shales. At the proposed injection site, the Dakota aquifer is estimated to be located at a depth of approximately 3,550 feet to 3,900 feet below ground surface (bgs), resulting in a thickness of approximately 350 feet. The Dakota aquifer is separated from the nearest USDW in McLean County, the Fox Hills Formation, by a 2,500-foot-thick confining unit composed of the Pierre shale and other shaley formations. The water chemistry of the Dakota aquifer at Coal Creek Station is poorly defined due to a lack of data near the site, although available data suggests that the TDS concentration is likely between 5,000 and 7,000 mg/L.

The Dakota aquifer does not currently serve as a source of drinking water near Coal Creek Station or in McLean County. A survey of wells was completed within the area of exemption and a surrounding ¼ mile buffer zone, as well as within McLean County. The survey found no wells of any type that penetrated the Dakota aquifer. The Dakota aquifer is commonly used to supply both public and private water systems in eastern North Dakota, where the aquifer is shallower and much more accessible; however, the closest Dakota aquifer water supply well to Coal Creek Station is approximately 60 miles northeast of the site.

The Dakota aquifer is economically impractical as a future source of drinking water in McLean County. Local consumers have many more accessible water supplies available to them, primarily the Missouri River and Lake Sakakawea (both surface water sources), in addition to shallow glacial aquifers. An economic evaluation suggests that using Dakota aquifer water as the drinking water supply for the nearby towns of Washburn or Underwood would be more costly than current water sources. Population projections for several municipalities in McLean County suggest that, despite recent energy activity in the western part of North Dakota, McLean County's population will remain fairly constant. Therefore, it is not expected that there will be a need to extract drinking water from the deep, more saline Dakota aquifer.

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TABLES

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Table 1-1: Drains Pond Water Chemistry

Sample ID	Date	General					Major Constituents						Minor Constituents												
		pH	TDS	Carbonate Alkalinity	Charge Imbalance Error	Water Type	Ca	Mg	Na	K	SO_4	Cl	Si	Total Organic Carbon	F	N	P	Li^+	Sr^{++}	B	As	Se	V	Al	Mn
		-	mg/kg	mg/L (as $CaCO_3$)	%	-	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L (as N)	mg/L (as P)	mg/L	mg/L	mg/L (as B)	mg/L (as As)	mg/L (as Se)	mg/L	mg/L	mg/L
1998 Average	9/15/2011	9	14349.7	174	0.00%	Na-SO_4	642.2	1142	1629		10402.7	622.8													
1998 Minimum	9/15/2011	8	9487	135	0.00%	Na-SO_4	437.4	372.3	1088		7130	457.7													
1998 Maximum	9/15/2011	9	18151.9	213	0.00%	Na-SO_4	760.7	1527	2137		13115.5	765.9													
Nov 2011 CCS	11/15/2011	8.34	11447	207.6	3.27%	Na-SO_4	587.8	1111	1387	184.8	7590	546													
Nov 2011 MVTL	11/15/2011	8.3	13300	186	1.38%	Na-SO_4	680	1230	1530	174	8800	476	43.2	25.6	7.55	24.35	0.5	0.84	12.6	76.64	0.26	0.04631	0.0397	0.25	
Dec 2011 CCS	12/14/2011	8.25	15288		0.00%	Mg-SO_4	604	1703	1562	210	10850	664													
Dec 2011 MVTL	12/14/2011	8.1	17700	182	8.12%	Mg-SO_4	760	2110	1880	222	11800	632	144	33.2	20.7	34.97		1.02	10.8	100.7	0.35	0.1114	0.0452	0.25	
Jan 2012 CCS	1/9/2012	7.98	18098.1		9.58%	Mg-SO_4	688	2386	1838	252	12627	692													
Jan 2012 MVTL	1/9/2012	7.9	21100	184	3.30%	Mg-SO_4	760	2580	1950	226	14500	664	79.2	30.8	27.2	38.51	0.77	1.08	8.8	92.65	0.3	0.1997	0.0414	0.25	0.35
Feb 2012 CCS	2/20/2012	8.48	15120.4	295	6.52%	Mg-SO_4	684	1780	1614	190	10248	557													
Feb 2012 MVTL	2/20/2012	8.4	16600	279	3.24%	Mg-SO_4	677	1760	1560	165	11300	573	74.9	29.5	31.2	6.3	0.41	1.00	9.9	13	0.19	0.11	0.0610	0.25	

See Section 4 in the permit application for a complete list of data sources.

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Table 1-2: Class II Saltwater Disposal Wells

File No.	Well Name	Spud Date	Injection Zone	Injection Interval (feet)	Est. Avg. Injection Rate (bpd)	Est. Max. Injection Rate (bpd)	Est. Avg. Injection Pressure (psi)	Est. Max. Injection Pressure (psi)	Avg. Observed TDS (mg/L)	Lowest Known Fresh Water Zone	County
90174	Cabernet SWD 1	12/16/2011	Dakota	5670-5740	2,000	2,500	1,300	1,500	274,394	Fox Hills	Dunn
90177	Madison 2-1	11/29/2011	Dakota	5597-5667	2,000	4,000	500	1,200	288,382	Fox Hills	McKenzie
90173	Alexander SWD 1	11/4/2011	Dakota (Inyan Kara)	5588-5925	600	12,000	1,000	1,500	179,588	Fox Hills	McKenzie
90162	Judy Disposal 1-27	10/16/2011	Inyan Kara/Dakota	5590-5786	2,000	2,400	200	1,400	252,713	Fox Hills	McKenzie
90164	Short Prairie 200-13 SWD	10/14/2011	Dakota	5570-6782	7,000	10,000	800	1,500	261,715	Fox Hills / Hell Creek	Williams
90168	Kandiyohi 200-33 SWD	10/6/2011	Dakota	5073-5133	7,000	10,000	800	1,350	230,192	Fox Hills / Hell Creek	Burke
90170	RCD 1	9/30/2011	Inyan Kara/Dakota	4890-5270	10,000	13,000	1,100	1,400	304,406	Fox Hills	McKenzie
90161	Justin SWD 1	9/11/2011	Inyan Kara/Dakota	4778-4822	10,000	15,000	1,000	1,400	177,564	Fox Hills / Hell Creek	Williams
90165	Dailey 1 SWD	9/2/2011	Dakota	5268-5456	3,000	5,000	1,000	1,200	276,165	Fox Hills	McKenzie
90157	SBG Manning Facility 1	8/29/2011	Inyan Kara/Dakota	5454-5682	10,000	12,000	600	1,500	218,995	Fox Hills / Hell Creek	Dunn
90166	Watford SWD 1	8/23/2011	Inyan Kara (Cretaceous)	5650-5890	10,000	14,000	1,000	1,500	127,705	Fox Hills	McKenzie
90153	Coteau 11-31 SWD	8/13/2011	Dakota Sand	4306-4330	2,000	3,000	800	1,150	277,508	Fox Hills	Burke
90159	13 Mile SWD 1	8/11/2011	Dakota	5202-5513	10,000	14,000	1,000	1,400	127,705	Fox Hills	Williams
90150	Comford 13-34 SWD	8/4/2011	Dakota	5072-5189	2,500	4,000	900	1,450	233,295	Fox Hills	Divide
90156	Gordon 1-22 SWD	7/31/2011	Dakota	5536-5916	3,000	5,000	900	1,500	310,044	Fox Hills	Williams
90151	Flatland 16-9 SWD	7/22/2011	Dakota	5421-5688	2,500	4,000	900	1,450	161,243	Fox Hills	McKenzie
90152	SDND 2	7/14/2011	Dakota	5070-5401	12,000	14,500	1,100	1,400	139,385	Fox Hills	Mountrail
90147	Belle SWD 5503 43-1	5/11/2011	Dakota	5572-5967	5,000	10,000	1,000	1,540	301,480	Fox Hills	Williams
90146	Erie SWD 5793 11-12	5/1/2011	Dakota	5082-5392	5,000	10,000	1,000	1,540	230,031	Fox Hills	Mountrail
90145	Trenton SWD 1	3/31/2011	Dakota	5559-5938	6,000	12,000	1,000	1,500	318,316	Fox Hills	Williams
90144	SBG Tioga Facility 1	3/11/2011	Dakota	5010-5170	7,500	10,000	500	1,350	199,712	Fox Hills / Hell Creek	Williams
90141	Christianson SWD 1	1/11/2011	Dakota	4620-4815	4,000	10,000	500	1,200	293,042	Fox Hills	Divide
90140	Wolter 16-23 SWD	11/15/2010	Dakota	4486-4560	1,800	3,000	100	1,100	166,161	Fox Hills	Divide
99189	Mann 33-18 SWD	10/16/2010	Dakota	5584-5668*	7,500	10,000	750	1,500	180,014	Fox HIlls	Stark
19585	Halek 5-22 1	10/2/2010	Dakota	5550-5812*	5,000	10,000	1,000	1,550	262,914	Fox Hills	Stark
90136	Wilco SWD 19 1	9/27/2010	Dakota	5600-6000	5,000	10,000	1,000	1,520	237,717	Fox Hills	Williams
90137	SDND 1	9/2/2010	Dakota Group	5260-5490	3,000	8,000	1,000	1,500	241,031	Fox Hills	Mountrail
90134	Rink SWD 2	8/26/2010	Dakota/Inyan Kara	5404-5580	2,000	2,400	200	1,400	245,280	Fox Hills	McKenzie
90135	Kannianen 43-5 SWD	8/3/2010	Inyan Kara/Dakota	5394-5532	7,500	10,000	750	1,500	143,820	Fox Hills / Hell Creek	Mountrail
99187	Mont 11-28 SWD	4/27/2010	Dakota	5985-6090	-	-	-	-	-	-	Williams
90132	Locken SWD 1	4/5/2010	Dakota/Inyan Kara	5246-5525	2,000	2,400	200	1,400	245,280	Fox Hills	Mountrail
90133	South Ross SWD 1	3/24/2010	Dakota	5390-5838	5,000	12,000	250	1,500	245,403	Fox Hills	Mountrail
18633	Aus 4-22	2/2/2010	Dakota	4721-4310	1,000	1,500	800	900	270,900	Fox Hills	Bottineau
90131	Thompson 1-SWD	11/27/2009	Dakota Group	5148-5246	1,000	3,000	200	1,200	218,682	Fox Hills	McKenzie
99186	Sidonia 100-06	4/8/2009	Dakota	4935-5158*	7,000	10,000	750	1,440	230,192	Fox Hills / Hell Creek	Mountrail
90126	Appledoorn SWD 1	1/7/2009	Dakota	5210-5400	3,000	5,000	500	1,450	262,896	Fox Hills	Dunn
90125	Miller 1 SWD	11/14/2008	Dakota	4356-4517	12,000	25,000	800	1,500	35,794	Fox Hills	Bowman
90123	Rink SWD 1	9/19/2008	Dakota	5324-5492	2,000	2,400	200	1,450	245,280	Fox Hills	McKenzie
90122	Zimmerman 1 SWD	8/23/2008	Dakota	5312-5462	1,000	2,500	200	1,500	184,991	Fox Hills	Williams
90119	Kulish 14-2 SWD	6/10/2008	Dakota	5620-5836	2,200	4,000	1,080	1,575	263,164	Fox Hills	Dunn
17058	Shell Creek 1-01 SWD	2/12/2008	Dakota	4690-5040	7,000	10,000	750	1,300	215,996	Fox Hills / Hell Creek	Mountrail
16862	Bloom SWD 1	11/11/2007	Inyan Kara	4860-4982	2,200	2,850	300	1,300	261,766	Fox Hills	Mountrail
16733	Wayzetta 100-26 SWD	10/24/2007	Dakota	4872-5437	7,000	10,000	750	1,430	225,383	Fox Hills / Hell Creek	Mountrail
90117	Dobias 1 SWD	10/2/2007	Dakota	5560-5721	1,000	2,500	100	800	254,356	Fox Hills	McKenzie
16649	Grace 1 SWD	5/23/2007	Inyan Kara	5734-5790	2,000	2,400	200	1,590	-	Fox Hills	Stark
90116	Irwin 1 SWD	5/8/2007	Dakota	5585-5910	2,500	4,000	100	800	247,923	Fox Hills	McKenzie
16564	S.E. 3-H	3/16/2007	Dakota/Inyan Kara	3446-3642	2,500	3,500	500	1,000	264,523	Fox Hills	Renville
14601	McKenzie Federal 35-1	6/5/1997	Dakota	4830-5070	200	250	150	150	263,590	Fort Union	McLean
13097	Hendrickson 42-28	1/6/1991	Dakota	4648-4782	500	1,500	50	800	290,155	Fox Hills	McLean
				Averages:	4,500	7,388	658	1,335	231,634		
				Average Injection Rate (gpm):	131	215					
				Medians:	3,000	6,500	750	1,435	245,280		
				Median Injection Rate (gpm):	88	190					

*Injection interval data taken from Form 14 (Form 6 missing).

This table includes saltwater disposal (SWD) wells designated as Active and having a spud date from 2007 to present. Also included are the only two SWD wells located in McLean County. Active SWD wells in North Dakota total 329 as of May 2012.

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Table 2-1: Local Geologic Structure

Geologic Unit	Stratigraphic Formations Included	Estimated Depth of Top of Unit (feet below ground surface)	Estimated Depth of Bottom of Unit (feet below ground surface)
Quaternary, Tertiary, and Upper Cretaceous Unit	Post-glacial sediments, Coleharbor, White River, Golden Valley, Fort Union Group, Hell Creek, Fox Hills	0	1,075
Cretaceous Confining Unit	Pierre, Niobrara, Carlile, Greenhorn, Belle Fourche, Mowry, Newcastle, Skull Creek	1,075	3,550
Dakota Group	Inyan Kara	3,550	3,900
Jurassic/Triassic/Permian Confining Unit	Morrison/Swift, Sundance, Piper, Spearfish, Minnekahta, Opeche	3,900	4,700
Minnelusa Formation	Minnelusa, Broom Creek, Amsden, Tyler	4,700	4,860
Kibbey Sandstone	Kibbey Sandstone	4,860	4,990
Mississippian Confining Unit	Big Snowy Group (Heath and Kibbey), Charles	4,990	5,520
Madison Group	Mission Canyon, Lodgepole	5,520	6,270
Bakken Shale	Bakken	6,270	--

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Table 2-2: Range of Water Chemistry Data for the Dakota Aquifer

Constituent	Minimum Concentration	Maximum Concentration	Mean Concentration	Mass Balance Concentration	Units
Ca++	3	7,182	134	71	mg/L
Mg++	1	442	35	20	mg/L
Na+	14	5,060	110	2,177	mg/L
HCO3-	19	2,125	621	844	mg/L
SO4--	0	7,560	970	753	mg/L
Cl-	94	175,921	3,201	2,531	mg/L
pH	6.3	8.9	7.9	7.9	-
K+	10	48	24	6	mg/L
TDS	1,992	256,782	7,116	6,369	mg/kg

See Section 4 in the permit application for a complete list of data sources.

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Table 3-1: List of All Active Water Supply Wells in McLean, Mercer, Oliver and Sheridan Counties (North Dakota)

NDSWC Site Index Number	County	Aquifer	Purpose	Depth (feet below ground surface)
7899	McLean	Fox Hills	Domestic Well	530
7900	McLean	Fort Union	Domestic Well	220
7901	McLean	Unknown	Domestic Well	120
7902	McLean	Unknown	Domestic Well	80
7905	McLean	Fort Union	Domestic Well	210
7906	McLean	Unknown	Domestic Well	300
7909	McLean	Fort Union	Domestic Well	110
7946	McLean	Unknown	Domestic Well	35
7956	McLean	Hell Creek	Domestic Well	350
7964	McLean	Fort Union	Domestic Well	310
7968	McLean	Fort Union	Domestic Well	220
7970	McLean	Unknown	Domestic Well	47
7972	McLean	Fort Union	Domestic Well	90
7975	McLean	Fort Union	Domestic Well	113
7976	McLean	Fort Union	Domestic Well	113
7977	McLean	Fort Union	Domestic Well	175
7983	McLean	Fort Union	Domestic Well	265
7985	McLean	Unknown	Domestic Well	150
7986	McLean	Fort Union	Domestic Well	30
7988	McLean	Fort Union	Domestic Well	210
7989	McLean	Unknown	Domestic Well	92
7994	McLean	Fox Hills	Domestic Well	605
7995	McLean	Hell Creek	Domestic Well	510
7996	McLean	Undefined	Domestic Well	16
7997	McLean	Hell Creek	Domestic Well	431
8002	McLean	Fort Union	Domestic Well	165
8007	McLean	Fort Union	Domestic Well	170
8009	McLean	Fort Union	Domestic Well	185
8020	McLean	Fox Hills	Domestic Well	530
8024	McLean	Fox Hills	Domestic Well	600
8058	McLean	Unknown	Domestic Well	16
8117	McLean	Fort Union	Domestic Well	140
8127	McLean	Fort Union	Domestic Well	380
8250	McLean	Lake Nettie	Domestic Well	70
8251	McLean	Lake Nettie	Domestic Well	87
8277	McLean	Fort Union	Domestic Well	80
8281	McLean	Fort Union	Domestic Well	95
8297	McLean	Fort Union	Domestic Well	113
8302	McLean	Fort Union	Domestic Well	87
8304	McLean	Fort Union	Domestic Well	40
8306	McLean	Fort Union	Domestic Well	50
8307	McLean	Fort Union	Domestic Well	150
8308	McLean	Fort Union	Domestic Well	47
8314	McLean	Tongue River	Domestic Well	60
8315	McLean	Unnamed	Domestic Well	150

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Table 3-1: List of All Active Water Supply Wells in McLean, Mercer, Oliver and Sheridan Counties (North Dakota)

NDSWC Site Index Number	County	Aquifer	Purpose	Depth (feet below ground surface)
8316	McLean	Fort Union	Domestic Well	226
8317	McLean	Fort Union	Domestic Well	80
8318	McLean	Fort Union	Domestic Well	36
8320	McLean	Undefined	Domestic Well	19
8324	McLean	Fort Union	Domestic Well	18
8332	McLean	White Shield	Domestic Well	13
8341	McLean	Unknown	Domestic Well	61
8342	McLean	Fort Union	Domestic Well	135
8343	McLean	Fort Union	Domestic Well	228
8366	McLean	Unnamed	Domestic Well	120
8368	McLean	Fort Union	Domestic Well	240
8369	McLean	Fort Union	Domestic Well	97
8371	McLean	Undefined	Domestic Well	150
8373	McLean	Unnamed	Domestic Well	45
8374	McLean	Fort Union	Domestic Well	30
8376	McLean	Unnamed	Domestic Well	85
8378	McLean	Fort Union	Domestic Well	100
8379	McLean	Tongue River	Domestic Well	87
8381	McLean	Fort Union	Domestic Well	220
8382	McLean	Fort Union	Domestic Well	140
8387	McLean	White Shield	Domestic Well	21
8390	McLean	Fort Union	Domestic Well	117
8418	McLean	Horseshoe Valley	Domestic Well	50
8440	McLean	Unnamed	Domestic Well	250
8441	McLean	Unnamed	Domestic Well	127
8447	McLean	Unnamed	Domestic Well	45
8449	McLean	Unnamed	Domestic Well	56
8450	McLean	Fort Union	Domestic Well	100
8452	McLean	Unnamed	Domestic Well	38
8453	McLean	Unnamed	Domestic Well	90
8457	McLean	Unnamed	Domestic Well	-
25319	McLean	Undefined	Domestic Well	588
33716	McLean	Lake Nettie	Domestic Well	23
33967	McLean	Lake Nettie	Domestic Well	345
124082	McLean	White Shield	Domestic Well	270
126193	McLean	Lake Nettie	Domestic Well	40
8149	McLean	Lake Nettie	Domestic Well	17
17688	McLean	Lake Nettie	Domestic Well	23
124979	McLean	Lake Nettie	Domestic Well	33
15527	McLean	Lake Nettie	Domestic Well	35
14675	McLean	Undefined	Domestic Well	38
124974	McLean	Lake Nettie	Domestic Well	38
1744	McLean	Lake Nettie	Domestic Well	40
15440	McLean	Lake Nettie	Domestic Well	40

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Table 3-1: List of All Active Water Supply Wells in McLean, Mercer, Oliver and Sheridan Counties (North Dakota)

NDSWC Site Index Number	County	Aquifer	Purpose	Depth (feet below ground surface)
124963	McLean	Lake Nettie	Domestic Well	40
124970	McLean	Lake Nettie	Domestic Well	41
15437	McLean	Lake Nettie	Domestic Well	46
14247	McLean	Lake Nettie	Domestic Well	50
124985	McLean	Lake Nettie	Domestic Well	52
29968	McLean	Lake Nettie	Domestic Well	59
1810	McLean	Lake Nettie	Domestic Well	60
1813	McLean	Lake Nettie	Domestic Well	70
14669	McLean	Lake Nettie	Domestic Well	60
15438	McLean	Lake Nettie	Domestic Well	60
124981	McLean	Lake Nettie	Domestic Well	60
8456	McLean	Fort Union	Domestic Well	65
8150	McLean	Lake Nettie	Domestic Well	71
14894	McLean	Lake Nettie	Domestic Well	75
15439	McLean	Lake Nettie	Domestic Well	75
14265	McLean	Lake Nettie	Domestic Well	77
14242	McLean	Lake Nettie	Domestic Well	80
14668	McLean	Lake Nettie	Domestic Well	80
14978	McLean	Lake Nettie	Domestic Well	90
14710	McLean	Lake Nettie	Domestic Well	92
8124	McLean	Lake Nettie	Domestic Well	97
14724	McLean	Wolf Creek	Domestic Well	100
15436	McLean	Lake Nettie	Domestic Well	100
14257	McLean	Lake Nettie	Domestic Well	115
14363	McLean	Fort Union	Domestic Well	120
14590	McLean	Fort Union	Domestic Well	132
14245	McLean	Lake Nettie	Domestic Well	153
14690	McLean	Undefined	Domestic Well	155
14723	McLean	Lake Nettie	Domestic Well	162
14758	McLean	Fort Union	Domestic Well	180
14316	McLean	Fort Union	Domestic Well	187
14673	McLean	Lake Nettie	Domestic Well	189
14198	McLean	Fort Union	Domestic Well	197
14721	McLean	Fort Union	Domestic Well	222
14674	McLean	Fort Union	Domestic Well	255
14286	McLean	Fort Union	Domestic Well	260
14204	McLean	Lake Nettie	Domestic Well	320
123735	McLean	White Shield	Domestic Well	330
14577	McLean	Fort Union	Domestic Well	340
14223	McLean	Fort Union	Domestic Well	402
14722	McLean	Fort Union	Domestic Well	422
8323	McLean	Unknown	Domestic Well	468
8128	McLean	Fort Union	Domestic Well	480
14246	McLean	Fort Union	Domestic Well	600

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Table 3-1: List of All Active Water Supply Wells in McLean, Mercer, Oliver and Sheridan Counties (North Dakota)

NDSWC Site Index Number	County	Aquifer	Purpose	Depth (feet below ground surface)
16175	McLean	Fox Hills	Domestic Well	733
8309	McLean	Fox Hills	Domestic Well	1323
8498	Mercer	Unknown	Domestic Well	-
8577	Mercer	Unknown	Domestic Well	-
8618	Mercer	Unknown	Domestic Well	54
15118	Mercer	Undefined	Domestic Well	-
31932	Mercer	Fox Hills	Domestic Well	840
8516	Mercer	Unknown	Domestic Well	34
8603	Mercer	Unknown	Domestic Well	40
8617	Mercer	Unknown	Domestic Well	40
126590	Mercer	Knife River	Domestic Well	60
126597	Mercer	Knife River	Domestic Well	65
126591	Mercer	Knife River	Domestic Well	70
126599	Mercer	Knife River	Domestic Well	70
126273	Mercer	Knife River	Domestic Well	76
126560	Mercer	Knife River	Domestic Well	76
8624	Mercer	Unknown	Domestic Well	80
126592	Mercer	Knife River	Domestic Well	94
8636	Mercer	Unknown	Domestic Well	96
8602	Mercer	Unknown	Domestic Well	100
126598	Mercer	Undefined	Domestic Well	120
126292	Mercer	Knife River	Domestic Well	125
8580	Mercer	Unknown	Domestic Well	146
126267	Mercer	Knife River	Domestic Well	147
8606	Mercer	Unknown	Domestic Well	150
126287	Mercer	Knife River	Domestic Well	159
126281	Mercer	Knife River	Domestic Well	160
126293	Mercer	Knife River	Domestic Well	160
126290	Mercer	Knife River	Domestic Well	161
126295	Mercer	Knife River	Domestic Well	168
126271	Mercer	Knife River	Domestic Well	175
126278	Mercer	Knife River	Domestic Well	175
126280	Mercer	Knife River	Domestic Well	175
126279	Mercer	Knife River	Domestic Well	177
126291	Mercer	Knife River	Domestic Well	178
126294	Mercer	Knife River	Domestic Well	180
126296	Mercer	Knife River	Domestic Well	180
126307	Mercer	Knife River	Domestic Well	180
126297	Mercer	Knife River	Domestic Well	195
126306	Mercer	Knife River	Domestic Well	196
126305	Mercer	Knife River	Domestic Well	200
126298	Mercer	Knife River	Domestic Well	210
126302	Mercer	Knife River	Domestic Well	236
126609	Mercer	Undefined	Domestic Well	460

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Table 3-1: List of All Active Water Supply Wells in McLean, Mercer, Oliver and Sheridan Counties (North Dakota)

NDSWC Site Index Number	County	Aquifer	Purpose	Depth (feet below ground surface)
8487	Mercer	Unknown	Domestic Well	500
8509	Mercer	Unknown	Domestic Well	740
126274	Mercer	Fox Hills	Domestic Well	840
8488	Mercer	Unknown	Domestic Well	880
8625	Mercer	Unknown	Domestic Well	1280
8486	Mercer	Fox Hills	Domestic Well	1300
8604	Mercer	Unknown	Domestic Well	1370
9480	Mercer	Unknown	Domestic Well	1460
9445	Oliver	Unknown	Domestic Well	-
9447	Oliver	Unknown	Domestic Well	65
9431	Oliver	Unknown	Domestic Well	140
9472	Oliver	Unknown	Domestic Well	294
10255	Sheridan	Unknown	Domestic Well	300
10325	Sheridan	Unknown	Domestic Well	40
10333	Sheridan	Lake Nettie	Domestic Well	260
10258	Sheridan	Unknown	Domestic Well	20
10279	Sheridan	Unknown	Domestic Well	75
10290	Sheridan	Unknown	Domestic Well	90
10384	Sheridan	Unknown	Domestic Well	98
10383	Sheridan	Unknown	Domestic Well	179
10370	Sheridan	Unknown	Domestic Well	178
10284	Sheridan	Unknown	Domestic Well	180
10262	Sheridan	Unknown	Domestic Well	230
10248	Sheridan	Undefined	Domestic Well	235
10256	Sheridan	Unknown	Domestic Well	240
10366	Sheridan	Unknown	Domestic Well	240
10269	Sheridan	Unknown	Domestic Well	255
10259	Sheridan	Unknown	Domestic Well	280
10388	Sheridan	Unknown	Domestic Well	287
10300	Sheridan	Unknown	Domestic Well	288
10303	Sheridan	Unknown	Domestic Well	295
10394	Sheridan	Unknown	Domestic Well	300
10283	Sheridan	Unknown	Domestic Well	326
10368	Sheridan	Unknown	Domestic Well	339
10330	Sheridan	Unknown	Domestic Well	380
10328	Sheridan	Unknown	Domestic Well	450
10253	Sheridan	Unknown	Domestic Well	480
10246	Sheridan	Unknown	Domestic Well	535
10291	Sheridan	Unknown	Domestic Well	750
8005	McLean	Undefined	Industrial Well	-
8180	McLean	Lake Nettie	Industrial Well	100.5
8181	McLean	Lake Nettie	Industrial Well	147
8495	Mercer	Unknown	Industrial Well	40
126288	Mercer	Knife River	Industrial Well	185

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Table 3-1: List of All Active Water Supply Wells in McLean, Mercer, Oliver and Sheridan Counties (North Dakota)

NDSWC Site Index Number	County	Aquifer	Purpose	Depth (feet below ground surface)
9459	Oliver	Unknown	Industrial Well	85
7960	McLean	Unknown	Irrigation Well	107
8328	McLean	White Shield	Irrigation Well	287
8330	McLean	White Shield	Irrigation Well	272
8416	McLean	Horseshoe Valley	Irrigation Well	21
8417	McLean	Horseshoe Valley	Irrigation Well	-
8419	McLean	Horseshoe Valley	Irrigation Well	-
8421	McLean	Horseshoe Valley	Irrigation Well	-
8425	McLean	Horseshoe Valley	Irrigation Well	69
8429	McLean	Horseshoe Valley	Irrigation Well	-
8431	McLean	Horseshoe Valley	Irrigation Well	-
8436	McLean	Strawberry Lake	Irrigation Well	-
123800	McLean	White Shield	Irrigation Well	340
12255	McLean	Lake Nettie	Irrigation Well	35
15526	McLean	Lake Nettie	Irrigation Well	35
15525	McLean	Lake Nettie	Irrigation Well	36
14229	McLean	Lake Nettie	Irrigation Well	45
15532	McLean	Lake Nettie	Irrigation Well	45
18738	McLean	Horseshoe Valley	Irrigation Well	45
15528	McLean	Lake Nettie	Irrigation Well	46
15531	McLean	Lake Nettie	Irrigation Well	46
14628	McLean	Horseshoe Valley	Irrigation Well	47
18733	McLean	Horseshoe Valley	Irrigation Well	47
1812	McLean	Lake Nettie	Irrigation Well	50
18736	McLean	Horseshoe Valley	Irrigation Well	50
18737	McLean	Horseshoe Valley	Irrigation Well	50
8357	McLean	Horseshoe Valley	Irrigation Well	52
15869	McLean	Lake Nettie	Irrigation Well	52
16174	McLean	Lake Nettie	Irrigation Well	53
14713	McLean	Lake Nettie	Irrigation Well	55
18734	McLean	Horseshoe Valley	Irrigation Well	56
18735	McLean	Undefined	Irrigation Well	61
15866	McLean	Lake Nettie	Irrigation Well	64
8354	McLean	Horseshoe Valley	Irrigation Well	65
14240	McLean	Lake Nettie	Irrigation Well	65
10336	McLean	Lake Nettie	Irrigation Well	66
8157	McLean	Lake Nettie	Irrigation Well	70
14267	McLean	Lake Nettie	Irrigation Well	98
14253	McLean	Lake Nettie	Irrigation Well	100
14256	McLean	Lake Nettie	Irrigation Well	100
15536	McLean	Lake Nettie	Irrigation Well	104
14755	McLean	Lake Nettie	Irrigation Well	150
123813	McLean	White Shield	Irrigation Well	195
13105	McLean	White Shield	Irrigation Well	210

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Table 3-1: List of All Active Water Supply Wells in McLean, Mercer, Oliver and Sheridan Counties (North Dakota)

NDSWC Site Index Number	County	Aquifer	Purpose	Depth (feet below ground surface)
123796	McLean	White Shield	Irrigation Well	270
123811	McLean	White Shield	Irrigation Well	295
123806	McLean	White Shield	Irrigation Well	300
8335	McLean	White Shield	Irrigation Well	310
123798	McLean	White Shield	Irrigation Well	320
123809	McLean	White Shield	Irrigation Well	340
8482	Mercer	Unknown	Irrigation Well	86
8544	Mercer	Knife River	Irrigation Well	105
126607	Mercer		Irrigation Well	-
126614	Mercer	Knife River	Irrigation Well	80
126561	Mercer	Knife River	Irrigation Well	86
126602	Mercer	Knife River	Irrigation Well	100
126285	Mercer	Knife River	Irrigation Well	160
126309	Mercer	Knife River	Irrigation Well	220
126277	Mercer	Knife River	Irrigation Well	293
9471	Oliver	Unknown	Irrigation Well	72
25290	Oliver	Missouri River	Irrigation Well	84
31377	Oliver	Missouri River	Irrigation Well	120
31378	Oliver	Missouri River	Irrigation Well	140
7919	McLean	Lost Lake	Municipal Well	55
7928	McLean	Lost Lake	Municipal Well	212
7978	McLean	Unknown	Municipal Well	-
7979	McLean	Unknown	Municipal Well	90
8017	McLean	Fox Hills	Municipal Well	585
8033	McLean	Fort Union	Municipal Well	82
8034	McLean	Fort Union	Municipal Well	95
8035	McLean	Fort Union	Municipal Well	87
8285	McLean	Fort Union	Municipal Well	258
8288	McLean	Garrison	Municipal Well	159
8289	McLean	Garrison	Municipal Well	200
8291	McLean	Garrison	Municipal Well	149
8292	McLean	Garrison	Municipal Well	30
8310	McLean	Unknown	Municipal Well	200
8311	McLean	Unknown	Municipal Well	205
8312	McLean	Unknown	Municipal Well	160
8313	McLean	Unknown	Municipal Well	154
8325	McLean	Unknown	Municipal Well	164
8344	McLean	Unknown	Municipal Well	215
8442	McLean	Unnamed	Municipal Well	12
8443	McLean	Unnamed	Municipal Well	130
8444	McLean	Unnamed	Municipal Well	23
13084	McLean	Lost Lake	Municipal Well	85
14260	McLean	Lake Nettie	Municipal Well	40
14708	McLean	Lake Nettie	Municipal Well	40

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Table 3-1: List of All Active Water Supply Wells in McLean, Mercer, Oliver and Sheridan Counties (North Dakota)

NDSWC Site Index Number	County	Aquifer	Purpose	Depth (feet below ground surface)
14261	McLean	Lake Nettie	Municipal Well	44
8108	McLean	Turtle Lake	Municipal Well	60
14785	McLean	Undefined	Municipal Well	60
7908	McLean	Fort Union	Municipal Well	103
14767	McLean	Turtle Lake	Municipal Well	107
7910	McLean	Fort Union	Municipal Well	108
8095	McLean	Fort Union	Municipal Well	445
14725	McLean	Fort Union	Municipal Well	608
8493	Mercer	Unknown	Municipal Well	-
8494	Mercer	Unknown	Municipal Well	270
8522	Mercer	Unknown	Municipal Well	-
8527	Mercer	Knife River	Municipal Well	69
8528	Mercer	Unknown	Municipal Well	65
8553	Mercer	Unknown	Municipal Well	-
8554	Mercer	Unknown	Municipal Well	-
8559	Mercer	Unknown	Municipal Well	-
8547	Mercer	Unknown	Municipal Well	114
8526	Mercer	Unknown	Municipal Well	120
8552	Mercer	Unknown	Municipal Well	126
126268	Mercer	Knife River	Municipal Well	170
8581	Mercer	Unknown	Municipal Well	1180
8561	Mercer	Fox Hills	Municipal Well	1515
9440	Oliver	Unknown	Municipal Well	119
9439	Oliver	Unknown	Municipal Well	130
9441	Oliver	Unknown	Municipal Well	139
10275	Sheridan	Unknown	Municipal Well	545
9454	Oliver	Missouri River	Production Well	115
10289	Sheridan	Fox Hills	Production Well	445
123934	McLean	White Shield	Rural Water Well	165
123945	McLean	White Shield	Rural Water Well	310
7992	McLean	Unknown	Stock Well	22
8126	McLean	Fort Union	Stock Well	73
8340	McLean	Unknown	Stock Well	42
8367	McLean	Unnamed	Stock Well	81
8389	McLean	Fort Union	Stock Well	130
8437	McLean	Hell Creek	Stock Well	618
8438	McLean	Unnamed	Stock Well	223
8445	McLean	Fort Union	Stock Well	117
8448	McLean	Unnamed	Stock Well	50
8451	McLean	Unnamed	Stock Well	33
8454	McLean	Unnamed	Stock Well	24
33968	McLean	Lake Nettie	Stock Well	-
8458	McLean	Fort Union	Stock Well	52
14310	McLean	Fort Union	Stock Well	183

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Table 3-1: List of All Active Water Supply Wells in McLean, Mercer, Oliver and Sheridan Counties (North Dakota)

NDSWC Site Index Number	County	Aquifer	Purpose	Depth (feet below ground surface)
8474	Mercer	Unknown	Stock Well	-
8483	Mercer	Unknown	Stock Well	35
8485	Mercer	Fox Hills	Stock Well	1280
17570	Mercer	Fox Hills	Stock Well	1380
17572	Mercer	Fox Hills	Stock Well	-
126284	Mercer	Knife River	Stock Well	155
8481	Mercer	Unknown	Stock Well	30
126559	Mercer	Knife River	Stock Well	50
126310	Mercer	Knife River	Stock Well	100
126596	Mercer	Knife River	Stock Well	100
8609	Mercer	Unknown	Stock Well	118
8629	Mercer	Unknown	Stock Well	125
126601	Mercer	Knife River	Stock Well	138
126300	Mercer	Knife River	Stock Well	140
126301	Mercer	Knife River	Stock Well	140
126299	Mercer	Knife River	Stock Well	157
126283	Mercer	Knife River	Stock Well	160
126282	Mercer	Knife River	Stock Well	165
126286	Mercer	Knife River	Stock Well	170
8535	Mercer	Unknown	Stock Well	243
9479	Mercer	Unknown	Stock Well	420
8504	Mercer	Unknown	Stock Well	483
8626	Mercer	Unknown	Stock Well	500
126594	Mercer	Fox Hills	Stock Well	500
8475	Mercer	Unknown	Stock Well	543
8541	Mercer	Unknown	Stock Well	630
8492	Mercer	Unknown	Stock Well	680
8523	Mercer	Unknown	Stock Well	730
126266	Mercer	Fox Hills	Stock Well	820
126311	Mercer	Fox Hills	Stock Well	850
126593	Mercer	Knife River	Stock Well	880
8514	Mercer	Fox Hills	Stock Well	900
8595	Mercer	Unknown	Stock Well	903
8521	Mercer	Unknown	Stock Well	1000
8596	Mercer	Unknown	Stock Well	1070
10821	Mercer	Fox Hills	Stock Well	1280
8468	Mercer	Unknown	Stock Well	1300
8627	Mercer	Unknown	Stock Well	1320
8464	Mercer	Unknown	Stock Well	1340
8463	Mercer	Unknown	Stock Well	1380
8585	Mercer	Unknown	Stock Well	1400
17571	Mercer	Fox Hills	Stock Well	1453
8473	Mercer	Unknown	Stock Well	1480
31379	Oliver	Missouri River	Stock Well	90

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Table 3-1: List of All Active Water Supply Wells in McLean, Mercer, Oliver and Sheridan Counties (North Dakota)

NDSWC Site Index Number	County	Aquifer	Purpose	Depth (feet below ground surface)
9434	Oliver	Unknown	Stock Well	350
9467	Oliver	Unknown	Stock Well	363
9450	Oliver	Unknown	Stock Well	1380
10362	Sheridan	Unknown	Stock Well	40
10278	Sheridan	Unknown	Stock Well	20
34165	Sheridan	Undefined	Stock Well	180
10265	Sheridan	Unknown	Stock Well	230
10268	Sheridan	Unknown	Stock Well	230
10263	Sheridan	Unknown	Stock Well	235
10266	Sheridan	Unknown	Stock Well	250
10294	Sheridan	Unknown	Stock Well	420
7936	McLean	Lost Lake	Unknown	190
7941	McLean	Unknown	Unknown	45
7947	McLean	Unknown	Unknown	16
7966	McLean	Unnamed	Unknown	130
7971	McLean	Unknown	Unknown	-
7984	McLean	Unknown	Unknown	260
7990	McLean	Unknown	Unknown	112
8012	McLean	Fort Union	Unknown	95
8036	McLean	Fort Union	Unknown	360
8056	McLean	Unknown	Unknown	-
8113	McLean	Fort Union	Unknown	-
8254	McLean	Lake Nettie	Unknown	60
8278	McLean	Fort Union	Unknown	139
8279	McLean	Fort Union	Unknown	167
8286	McLean	Garrison	Unknown	-
8305	McLean	Unnamed	Unknown	-
8329	McLean	White Shield	Unknown	260
8375	McLean	Unnamed	Unknown	-
8446	McLean	Fort Union	Unknown	150
7907	McLean	Fort Union	Unknown	100
8537	Mercer	Unknown	Unknown	-
8546	Mercer	Unknown	Unknown	-
8548	Mercer	Unknown	Unknown	300
8549	Mercer	Unknown	Unknown	120
8578	Mercer	Unknown	Unknown	-
8584	Mercer	Unknown	Unknown	-
8601	Mercer	Unknown	Unknown	-
8631	Mercer	Unknown	Unknown	-
9478	Mercer	Unknown	Unknown	-
8472	Mercer	Unknown	Unknown	22
8614	Mercer	Unknown	Unknown	100
8543	Mercer	Unknown	Unknown	120
8534	Mercer	Unknown	Unknown	243

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Table 3-1: List of All Active Water Supply Wells in McLean, Mercer, Oliver and Sheridan Counties (North Dakota)

NDSWC Site Index Number	County	Aquifer	Purpose	Depth (feet below ground surface)
8507	Mercer	Unknown	Unknown	450
8480	Mercer	Unknown	Unknown	840
8479	Mercer	Unknown	Unknown	880
8478	Mercer	Unknown	Unknown	960
8598	Mercer	Unknown	Unknown	964
8542	Mercer	Unknown	Unknown	1144
8587	Mercer	Unknown	Unknown	1260
8586	Mercer	Unknown	Unknown	1265
9418	Oliver	Unknown	Unknown	-
9419	Oliver	Unknown	Unknown	-
9420	Oliver	Unknown	Unknown	-
9421	Oliver	Unknown	Unknown	-
9422	Oliver	Unknown	Unknown	-
9446	Oliver	Unknown	Unknown	-
9449	Oliver	Unknown	Unknown	67
9425	Oliver	Unknown	Unknown	70
9426	Oliver	Unknown	Unknown	76
9473	Oliver	Unknown	Unknown	284
9433	Oliver	Unknown	Unknown	313
10287	Sheridan	Unknown	Unknown	-
10339	Sheridan	Unknown	Unknown	18
10340	Sheridan	Unknown	Unknown	300
10341	Sheridan	Unknown	Unknown	24
10342	Sheridan	Unknown	Unknown	150
10343	Sheridan	Unknown	Unknown	380
10344	Sheridan	Unknown	Unknown	30
10345	Sheridan	Unknown	Unknown	160
10347	Sheridan	Unknown	Unknown	220
10349	Sheridan	Unknown	Unknown	580
10351	Sheridan	Unknown	Unknown	165
10354	Sheridan	Unknown	Unknown	601
10356	Sheridan	Unknown	Unknown	500
10357	Sheridan	Unknown	Unknown	100
10358	Sheridan	Unknown	Unknown	130
10363	Sheridan	Unknown	Unknown	160
10364	Sheridan	Unknown	Unknown	210
10365	Sheridan	Unknown	Unknown	90
10367	Sheridan	Unknown	Unknown	12
10369	Sheridan	Unknown	Unknown	165
10372	Sheridan	Unknown	Unknown	126
10374	Sheridan	Unknown	Unknown	340
10377	Sheridan	Unknown	Unknown	115
10378	Sheridan	Unknown	Unknown	280
10381	Sheridan	Unknown	Unknown	27

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Table 3-1: List of All Active Water Supply Wells in McLean, Mercer, Oliver and Sheridan Counties (North Dakota)

NDSWC Site Index Number	County	Aquifer	Purpose	Depth (feet below ground surface)
10382	Sheridan	Unknown	Unknown	35
10385	Sheridan	Unknown	Unknown	74
10389	Sheridan	Unknown	Unknown	249
10390	Sheridan	Unknown	Unknown	30
10392	Sheridan	Unknown	Unknown	37
10393	Sheridan	Unknown	Unknown	-
10395	Sheridan	Unknown	Unknown	95
10396	Sheridan	Unknown	Unknown	50
10397	Sheridan	Unknown	Unknown	98
12888	Sheridan	Undefined	Unknown	-
10285	Sheridan	Unknown	Unknown	17
10348	Sheridan	Unknown	Unknown	40
10298	Sheridan	Unknown	Unknown	90
10301	Sheridan	Unknown	Unknown	90
10273	Sheridan	Unknown	Unknown	100
10309	Sheridan	Unknown	Unknown	110
10313	Sheridan	Unknown	Unknown	148
10321	Sheridan	Unknown	Unknown	160
10335	Sheridan	Unknown	Unknown	180
10306	Sheridan	Unknown	Unknown	207
10247	Sheridan	Unknown	Unknown	260
10315	Sheridan	Unknown	Unknown	285
10295	Sheridan	Unknown	Unknown	303
10280	Sheridan	Unknown	Unknown	310
10272	Sheridan	Unknown	Unknown	320
10304	Sheridan	Unknown	Unknown	320
10261	Sheridan	Unknown	Unknown	325
10270	Sheridan	Unknown	Unknown	348
10249	Sheridan	Unknown	Unknown	370
10329	Sheridan	Unknown	Unknown	370
10288	Sheridan	Unknown	Unknown	377
10311	Sheridan	Unknown	Unknown	436
10276	Sheridan	Unknown	Unknown	600
10305	Sheridan	Unknown	Unknown	640
10281	Sheridan	Unknown	Unknown	678
10312	Sheridan	Unknown	Unknown	680
			Maximum Depth (feet bgs)	**1515**

Note: All well information obtained from the North Dakota State Water Commission website.

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Table 3-2: Wells Near the Proposed Exemption Area

Map Well Number	State Drillers' Logs Index Number	State Groundwater Resources Index Number	GRE Monitoring Well Number	Northing (ft - ND State Plane N 3301)	Easting (ft - ND State Plane N 3301)	Owner	Purpose	Depth (ft)
1	-	-	9	138982	1810759	Great River Energy	Monitoring Well	55
2	-	-	10	138982	1810759	Great River Energy	Monitoring Well	29
3	-	-	12	140202	1812311	Great River Energy	Monitoring Well	88
4	-	-	13	140202	1812311	Great River Energy	Monitoring Well	88
5	-	-	14	140202	1812311	Great River Energy	Monitoring Well	88
6	-	-	15	138581	1814848	Great River Energy	Monitoring Well	38
7	63504	-	16-1	139269	1812416	Great River Energy	Monitoring Well	11.5
8	63506	-	16-2	139269	1813166	Great River Energy	Monitoring Well	12
9	63508	-	16-3	139269	1813916	Great River Energy	Monitoring Well	12
10	63510	-	16-4	139269	1814666	Great River Energy	Monitoring Well	17
11	63512	-	16-5	137839	1814637	Great River Energy	Monitoring Well	11.5
12	-	-	17	142400	1812740	Great River Energy	Monitoring Well	17
13	-	-	18	142428	1813359	Great River Energy	Monitoring Well	17
14	-	-	21	142780	1811323	Great River Energy	Monitoring Well	19
15	-	-	23	145384	1814626	Great River Energy	Monitoring Well	40
16	-	-	29	144727	1808963	Great River Energy	Monitoring Well	28
17	-	-	31	144023	1807879	Great River Energy	Monitoring Well	25
18	-	-	32	144023	1807879	Great River Energy	Monitoring Well	13
19	-	-	33	144417	1806914	Great River Energy	Monitoring Well	33
20	-	-	38	146708	1807660	Great River Energy	Monitoring Well	28
21	27080	-	44	138334	1815904	Great River Energy	Monitoring Well	15
22	27079	-	45	138334	1815904	Great River Energy	Monitoring Well	35
23	27094	-	49	138932	1808728	Great River Energy	Monitoring Well	19.85
24	27084	-	50	138919	1809517	Great River Energy	Monitoring Well	22.88
25	27085	-	51	138934	1810274	Great River Energy	Monitoring Well	18.8
26	27098	-	62	139099	1804633	Great River Energy	Monitoring Well	43.3
27	27100	-	63	138223	1804218	Great River Energy	Monitoring Well	42.4
28	27101	-	65	138223	1804218	Great River Energy	Monitoring Well	24
29	57797	-	69	140189	1810721	Great River Energy	Monitoring Well	17.8
30	57798	-	70	140400	1813222	Great River Energy	Monitoring Well	12.3
31	57800	-	72	136784	1812426	Great River Energy	Monitoring Well	23
32	57803	-	75	136290	1808116	Great River Energy	Monitoring Well	40.5
33	57807	-	79	145800	1809005	Great River Energy	Monitoring Well	21
34	57808	-	80	144924	1805994	Great River Energy	Monitoring Well	16.5
35	57814	-	87	142357	1814612	Great River Energy	Monitoring Well	9
36	57816	-	89	143550	1811344	Great River Energy	Monitoring Well	10.5
37	44455	-	95	136407	1804257	Great River Energy	Monitoring Well	20
38	44456	-	96	136407	1804257	Great River Energy	Monitoring Well	45
39	-	-	208	141100	1804692	Great River Energy	Monitoring Well	Unknown
40	27066	-	541	149383	1806099	Great River Energy	Monitoring Well	74.33
41	27067	-	542	149383	1806099	Great River Energy	Monitoring Well	46.6
42	-	-	1	145524	1805317	Great River Energy	Monitoring Well - Abandoned	73
43	-	-	2	145524	1805317	Great River Energy	Monitoring Well - Abandoned	73
44	-	-	3	144547	1805428	Great River Energy	Monitoring Well - Abandoned	38
45	-	-	4	143932	1804991	Great River Energy	Monitoring Well - Abandoned	35
46	-	-	5	144511	1804249	Great River Energy	Monitoring Well - Abandoned	33
47	-	-	6	137833	1808290	Great River Energy	Monitoring Well - Abandoned	92
48	-	-	7	141235	1809121	Great River Energy	Monitoring Well - Abandoned	68
49	-	-	8	141240	1809120	Great River Energy	Monitoring Well - Abandoned	68
50	-	-	11	141321	1810438	Great River Energy	Monitoring Well - Abandoned	53
51	-	-	16	143075	1814648	Great River Energy	Monitoring Well - Abandoned	23
52	-	-	20	142780	1811323	Great River Energy	Monitoring Well - Abandoned	31.5
53	-	-	22	142780	1811323	Great River Energy	Monitoring Well - Abandoned	10
54	-	-	24	145384	1814626	Great River Energy	Monitoring Well - Abandoned	25
55	-	-	25	145388	1814622	Great River Energy	Monitoring Well - Abandoned	13.5
56	-	-	26	144756	1811920	Great River Energy	Monitoring Well - Abandoned	43
57	-	-	27	144756	1811920	Great River Energy	Monitoring Well - Abandoned	33
58	-	-	28	144756	1811920	Great River Energy	Monitoring Well - Abandoned	23
59	-	-	30	144023	1807879	Great River Energy	Monitoring Well - Abandoned	42.5
60	-	-	34	145933	1805892	Great River Energy	Monitoring Well - Abandoned	54
61	-	-	35	145933	1805892	Great River Energy	Monitoring Well - Abandoned	33
62	-	-	36	145933	1805892	Great River Energy	Monitoring Well - Abandoned	18
63	-	-	37	145219	1804862	Great River Energy	Monitoring Well - Abandoned	20
64	-	-	39	146630	1813064	Great River Energy	Monitoring Well - Abandoned	29
65	27074	-	40	142042	1807290	Great River Energy	Monitoring Well - Abandoned	16.5
66	27075	-	41	141028	1807795	Great River Energy	Monitoring Well - Abandoned	21.5
67	27082	-	42	136805	1813460	Great River Energy	Monitoring Well - Abandoned	16.5
68	27083	-	43	137109	1814597	Great River Energy	Monitoring Well - Abandoned	16.5
69	27081	-	46	136814	1816175	Great River Energy	Monitoring Well - Abandoned	31.5
70	27077	-	47	143757	1816819	Great River Energy	Monitoring Well - Abandoned	36.5
71	27093	-	48	139887	1808678	Great River Energy	Monitoring Well - Abandoned	43.5
72	27089	-	52	138321	1811418	Great River Energy	Monitoring Well - Abandoned	55
73	27088	-	53	137563	1811418	Great River Energy	Monitoring Well - Abandoned	45
74	27087	-	54	137040	1811400	Great River Energy	Monitoring Well - Abandoned	38
75	27086	-	55	137035	1810102	Great River Energy	Monitoring Well - Abandoned	35
76	27103	-	56	136908	1808884	Great River Energy	Monitoring Well - Abandoned	30
77	27104	-	57	137503	1808117	Great River Energy	Monitoring Well - Abandoned	45
78	27105	-	58	138183	1807806	Great River Energy	Monitoring Well - Abandoned	30
79	27106	-	59	138841	1808400	Great River Energy	Monitoring Well - Abandoned	30
80	27095	-	60	139683	1806720	Great River Energy	Monitoring Well - Abandoned	42.5
81	27107	-	61	137185	1807058	Great River Energy	Monitoring Well - Abandoned	45
82	27099	-	64	139099	1804633	Great River Energy	Monitoring Well - Abandoned	25
83	27090	-	66	139966	1808094	Great River Energy	Monitoring Well - Abandoned	40
84	27092	-	67	140704	1808265	Great River Energy	Monitoring Well - Abandoned	45
85	27091	-	68	140664	1808660	Great River Energy	Monitoring Well - Abandoned	42.5
86	57799	-	71	137058	1808113	Great River Energy	Monitoring Well - Abandoned	44.5
87	57801	-	73	138713	1812370	Great River Energy	Monitoring Well - Abandoned	28

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Table 3-2: Wells Near the Proposed Exemption Area

Map Well Number	State Drillers' Logs Index Number	State Groundwater Resources Index Number	GRE Monitoring Well Number	Northing (ft - ND State Plane N 3301)	Easting (ft - ND State Plane N 3301)	Owner	Purpose	Depth (ft)
88	57802	-	74	136280	1809351	Great River Energy	Monitoring Well - Abandoned	39.5
89	57804	-	76	137793	1807507	Great River Energy	Monitoring Well - Abandoned	17.4
90	57805	-	77	146462	1805993	Great River Energy	Monitoring Well - Abandoned	34.5
91	57806	-	78	146474	1809003	Great River Energy	Monitoring Well - Abandoned	20
92	-	-	81	145850	1807003	Great River Energy	Monitoring Well - Abandoned	30
93	57809	-	82	145809	1808000	Great River Energy	Monitoring Well - Abandoned	27
94	57810	-	83	146454	1811022	Great River Energy	Monitoring Well - Abandoned	19.5
95	57811	-	84	145511	1811137	Great River Energy	Monitoring Well - Abandoned	14.7
96	57812	-	85	144775	1813489	Great River Energy	Monitoring Well - Abandoned	24
97	57813	-	86	144036	1814646	Great River Energy	Monitoring Well - Abandoned	23.3
98	57815	-	88	142076	1811664	Great River Energy	Monitoring Well - Abandoned	14.5
99	57817	-	90	143578	1811743	Great River Energy	Monitoring Well - Abandoned	9
100	57818	-	91	143508	1812843	Great River Energy	Monitoring Well - Abandoned	32
101	57819	-	92	137219	1809521	Great River Energy	Monitoring Well - Abandoned	9.8
102	57820	-	93	137479	1809779	Great River Energy	Monitoring Well - Abandoned	13.3
103	57821	-	94	137484	1809784	Great River Energy	Monitoring Well - Abandoned	33.7
104	-	-	209	141397	1804529	Great River Energy	Monitoring Well - Abandoned	Unknown
105	-	-	322	143936	1805417	Great River Energy	Monitoring Well - Abandoned	Unknown
106	-	-	323	143841	1805417	Great River Energy	Monitoring Well - Abandoned	Unknown
107	27062	-	537	149105	1804524	Great River Energy	Monitoring Well - Abandoned	72
108	27063	-	538	149105	1804524	Great River Energy	Monitoring Well - Abandoned	51.5
109	27064	-	539	149248	1805267	Great River Energy	Monitoring Well - Abandoned	60
110	27065	-	540	149248	1805267	Great River Energy	Monitoring Well - Abandoned	43
111	27076	-	-	144074	1811908	Great River Energy	Monitoring Well	54
112	44457	-	-	138406	1815527	Falkirk Mining Co.	Monitoring Well	13
113	57822	-	-	139091	1813522	Great River Energy	Monitoring Well	14.5
114	57823	-	-	138407	1814178	Great River Energy	Monitoring Well	35
115	57825	-	-	137740	1812851	Great River Energy	Monitoring Well	45
116	57824	-	-	137057	1813506	Great River Energy	Monitoring Well	40
117	44451	-	-	140473	1804287	Great River Energy	Monitoring Well	24
118	44452	-	-	140473	1804287	Great River Energy	Monitoring Well	52
119	44453	-	-	140468	1804941	Great River Energy	Monitoring Well	52
120	44454	-	-	140468	1804941	Great River Energy	Monitoring Well	24
121	63514	-	-	138168	1804715	Great River Energy	Monitoring Well	30
122	63516	-	-	138168	1804715	Great River Energy	Monitoring Well	30
123	63518	-	-	138168	1804715	Great River Energy	Monitoring Well	32
124	27108	30387	-	136513	1804254	Falkirk Mining Co.	Monitoring Well	205
125	27109	30388	-	136513	1804254	Falkirk Mining Co.	Monitoring Well	157
126	27102	-	-	137156	1806222	University of North Dakota	Monitoring Well	80
127	27097	-	-	138454	1808849	University of North Dakota	Monitoring Well	50
128	27096	-	-	137140	1808184	University of North Dakota	Monitoring Well	57
129	57796	-	-	147710	1807619	Falkirk Mining Co.	Monitoring Well	21.5
130	57795	-	-	147710	1807619	Falkirk Mining Co.	Monitoring Well	21.5
131	27111	-	-	135895	1804920	University of North Dakota	Monitoring Well	100
132	-	30320	-	147040	1811033	Falkirk Mining Co.	Observation Well	20
133	-	30322	-	147047	1814364	Falkirk Mining Co.	Observation Well	41
134	-	30323	-	147047	1814364	Falkirk Mining Co.	Observation Well	25
135	-	30334	-	149046	1807086	Falkirk Mining Co.	Observation Well	62
136	-	30335	-	149046	1807086	Falkirk Mining Co.	Observation Well	48
137	-	30336	-	149046	1807086	Falkirk Mining Co.	Observation Well	27
138	-	30383	-	143807	1803745	Falkirk Mining Co.	Observation Well	0
139	-	30319	-	147040	1811033	Falkirk Mining Co.	Observation Well - Plugged	42.5
140	-	8010	-	143807	1803745	ND State Water Commission	Observation Well - Plugged	280
141	-	30330	-	149029	1809060	Falkirk Mining Co.	Observation Well - Destroyed	280
142	-	30331	-	149029	1809060	Falkirk Mining Co.	Observation Well - Destroyed	178
143	-	30332	-	149029	1809060	Falkirk Mining Co.	Observation Well - Destroyed	89
144	-	30333	-	149029	1809060	Falkirk Mining Co.	Observation Well - Destroyed	27
145	-	30384	-	144402	1809024	Falkirk Mining Co.	Observation Well - Destroyed	390
146	-	30385	-	144402	1809024	Falkirk Mining Co.	Observation Well - Destroyed	340
147	-	30386	-	144402	1809024	Falkirk Mining Co.	Observation Well - Destroyed	190
148	27070	-	-	144087	1806607	United Power Association	Industrial Well	304
149	27072	-	-	144087	1806607	United Power Association	Industrial Well	264
150	27073	-	-	144087	1806607	United Power Association	Industrial Well	234
151	27055	-	-	149350	1811952	Falkirk Mining Co.	Industrial Well	60
152	27071	-	-	144087	1806607	United Power Association	Test Hole	254
153	-	23482	-	141727	1817505	ND State Water Commission	Test Hole	140

Notes

1) Well records and locations for Great River Energy (GRE) monitoring wells obtained from GRE. When possible, North Dakota State Water Commission well records were matched to GRE records. All additional well records and locations were obtained from ND State Water Commission drillers' and water well databases.

2) Sources: GRE records, North Dakota State Water Commission drillers' logs and water well databases, North Dakota Industrial Commission (NDIC)

3) "Depth" is defined as the drilled depth of each well. When drilled depths were not made available, the completion depth was provided.

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Table 4-2: Economic Evaluation Summary

Total Costs Associated with a Dakota Aquifer Water System				
	Value			
Item	**Washburn**	**Underwood**	**Unit**	**Source**
General System Characteristics				
Population (2011)	1261	788	-	US Census data
Infrastructure Design Flow Rate	500	200	gpm	Golder estimate
Distance to Coal Creek Station	8.4	6.2	mi	Golder estimate
Volume of Water Produced Annually	74,000,000	31,000,000	gal	Data provided by towns
Average Water Usage Flow Rate	141	59	gpm	Calculated
Capital Costs				
Power	$150,000	$150,000	-	Golder estimate
Well Pumps and Infrastructure	$40,000	$31,000	-	See Table C-1
Pipeline	$3,163,000	$2,343,000	-	See Table C-2
Wells	$1,674,000	$1,247,000	-	See Table C-3
Water Treatment Facilities	$6,215,000	$3,587,000	-	See Table C-4
Total Capital Costs	$11,242,000	$7,358,000	-	Summation
O&M Costs				
Well Pumps	$15,000	$9,000	$/yr	See Table C-5
Water Treatment	$414,000	$331,000	$/yr	See Table C-6
Total O&M Costs	$429,000	$340,000	$/yr	Summation
Cost of Water				
Bond Term	10	10	yr	Golder estimate
Volume of Water Produced Over Bond Term	740,000,000	310,000,000	gal	Calculated
Annual Capital Cost to Ratepayers	$1,431,000	$937,000	-	See Table C-7
Total Costs Over Bond Term	$18,600,000	$12,770,000	-	Calculated
Cost Per 1000 Gallons of Water	**$25.14**	**$41.19**	$/1000	Calculated

Current Cost of Water

	Value			
Item	**Washburn**	**Underwood**	**Unit**	**Source**
Base Rate (0 - 2000 Gallons)	$37.00	$18.00	$	Data provided by towns
Surplus Rate Per 1000 Gallons of Water	$3.00	$3.25	$/1000	Data provided by towns
Estimated Per Capita Water Use (Daily)	161	108	gpdc	Calculated
Estimated Per Capita Water Use (Monthly)	4,890	3,278	gal/month	Calculated
Current Cost Per 1000 Gallons of Water	**$9.34**	**$6.76**	$/1000	Calculated

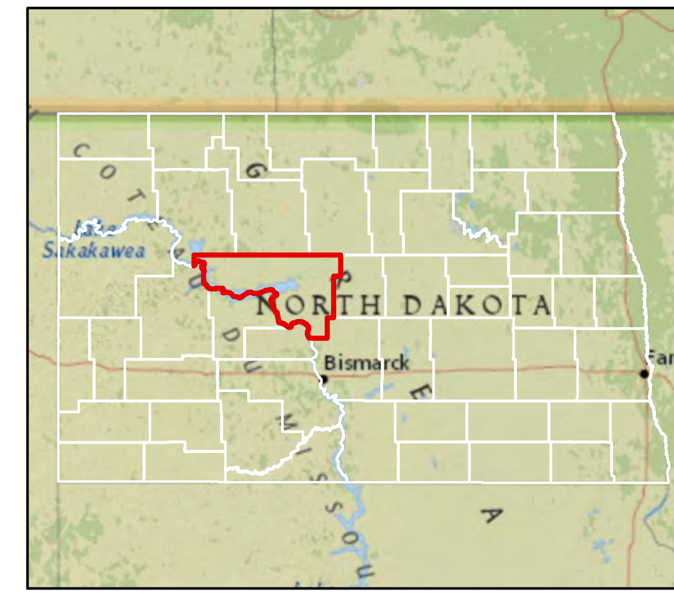
Cost Comparison

	Value			
Item	**Washburn**	**Underwood**	**Unit**	**Source**
Variance From Current Cost	170%	510%	-	Calculated
Ratio of Dakota Cost to Current Cost	2.7	6.1	-	Calculated

FIGURES

LEGEND

- Proposed Injection Site
- County Boundary



REFERENCES

Coordinate System: NAD 1983 StatePlane North Dakota South FIPS 3302 Feet.
Basemap: (c) 2010 Microsoft Corporation and its data suppliers.
Inset Basemap: National Geographic, Esri, DeLorme, NAVTEQ, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, iPC

8 4 0 8 MILES

SCALE 1:506,880 1 INCH = 8 MILES
WHEN PRODUCED AT SIZE 11X17IN

PROJECT

GREAT RIVER ENERGY
UNDERGROUND INJECTION WELL
UNDERWOOD, NORTH DAKOTA

TITLE

SITE LOCATION

Golder Associates
Denver, Colorado

PROJECT No.		11382051	FILE No.	Fig1-1_Site Location.mxd
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GIS	KJC	11/29/2012		1-1
CHECK	SCA	11/29/2012		
REVIEW	RRJ	11/29/2012		

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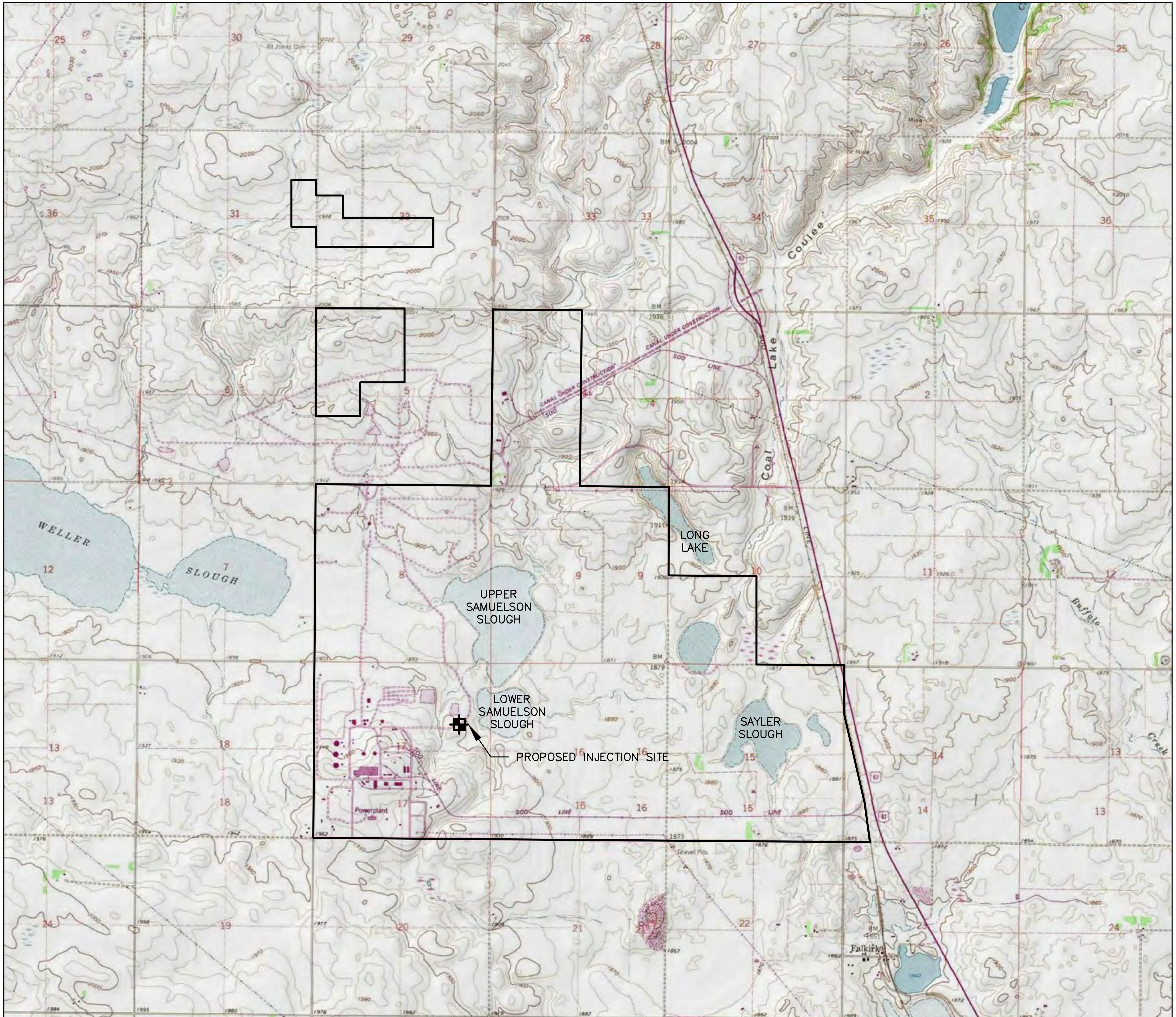

LEGEND

GRE PROPERTY BOUNDARIES

PROPOSED INJECTION SITE

NOTES

1. PROPOSED INJECTION SITE IS LOCATED IN TOWNSHIP 145N, RANGE 82W.

REFERENCES

1. ELECTRONIC TOPOGRAPHIC IMAGE OBTAINED FROM THE UNITED STATES GEOLOGIC SURVEY.
2. TOPOGRAPHIC QUADRANGLE MAPS WERE ORIGINALLY PRODUCED IN 1961 AND 1967, AND PHOTOREVISED IN 1980.

3000 0 3000

1" = 3,000' FEET

PROJECT

GREAT RIVER ENERGY
UNDERGROUND INJECTION WELL
UNDERWOOD, NORTH DAKOTA

TITLE

INJECTION SITE VICINITY

Golder Associates

PROJECT No.	113-82051		FILE No.	11382051C001
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CADD	AMS	11/20/12		
CHECK	SCA	11/20/12	1-2	
REVIEW	RRJ	11/20/12		

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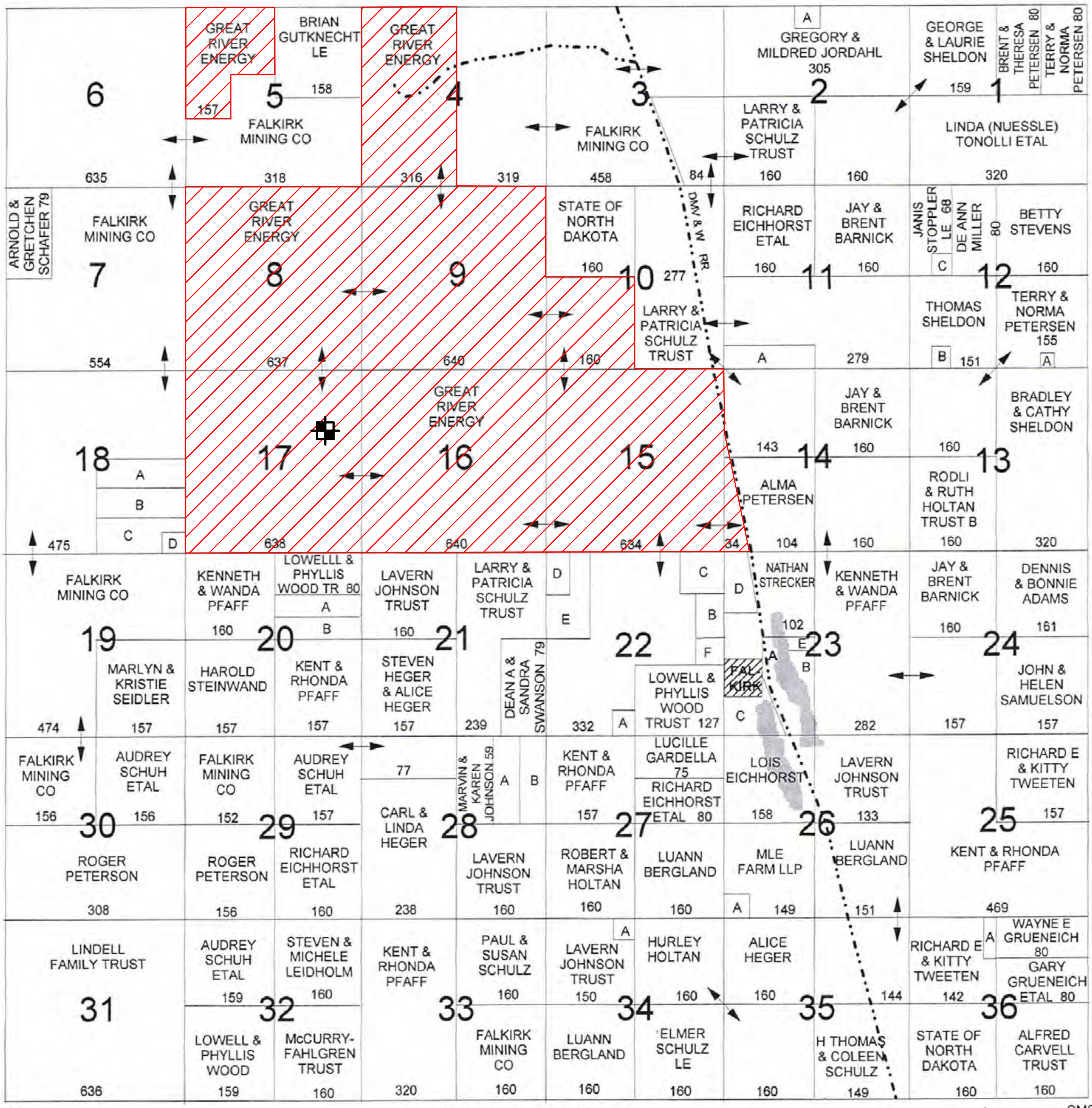
TWP 145N - R82W PLAT

T-145-N

CODE: CG

R-82-W



ET

CMS

SMALL TRACT OWNERS

2-A DANIEL & LORI GEFROH - 12 ACRES
11-A EUGENE & PATRICIA HAGER - 40 ACRES
12-A KELLY & PAMELA TRUEBLOOD - 5 ACRES
12-B ROBERT & JILL WIESE - 9 ACRES
12-C SHANE STEVENS - 13 ACRES
18-A JANICE BERGET - 50 ACRES
18-B MICHAEL JOHNSON - 50 ACRES
18-C CHAD STEVAHN ETAL - 50 ACRES
18-D KEVIN JOHNSON ETAL - 10 ACRES
20-A MARVIN & KAREN JOHNSON - 40 ACRES
20-B L LEROY & SHIRLEY JOHNSON - 40 ACRES
22-A MILES GRADIN - 10 ACRES
22-B FRANCESCO FODERA - 26 ACRES
22-C BURL & KAREN SORENSON - 46 ACRES
22-D STATE OF NORTH DAKOTA - 18 ACRES
22-E RODNEY BACKMAN - 62 ACRES
22-F MARY LEMCKE - 13 ACRES
23-A FALKIRK FARMERS ELEVATOR - 9 ACRES
23-B T ALDONNA BROWN - 49 ACRES
23-C KELLY SIMENSON - 36 ACRES
23-D RICKY & CARLA ARROWSMITH - 42 ACRES
23-E JEFFREY & GERTRUDE SHOEMAKER - 6 ACRES
26-A CALVIN EICHHORST - 12 ACRES
28-A CLAYTON & ELAINE CARR - 49 ACRES
28-B MARGO JOHNSON - 49 ACRES
34-A ALDONNA BROWN - 10 ACRES
36-A BRIAN & SANDI ERBER - 10 ACRES

LEGEND

GREAT RIVER ENERGY PROPERTY BOUNDARIES

RAILROAD

PROPOSED INJECTION SITE

REFERENCES

1. PLAT OBTAINED FROM THE MCLEAN COUNTY TAX EQUALIZATION OFFICE IN FEBRUARY 2012.

0.5 0 0.5
SCALE MILES

PROJECT
GREAT RIVER ENERGY
UNDERGROUND INJECTION WELL
UNDERWOOD, NORTH DAKOTA

TITLE
LANDOWNERSHIP

Golder Associates

PROJECT No.	113-82051	FILE No.	11382051C002
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REVIEW	RRJ	11/20/12	

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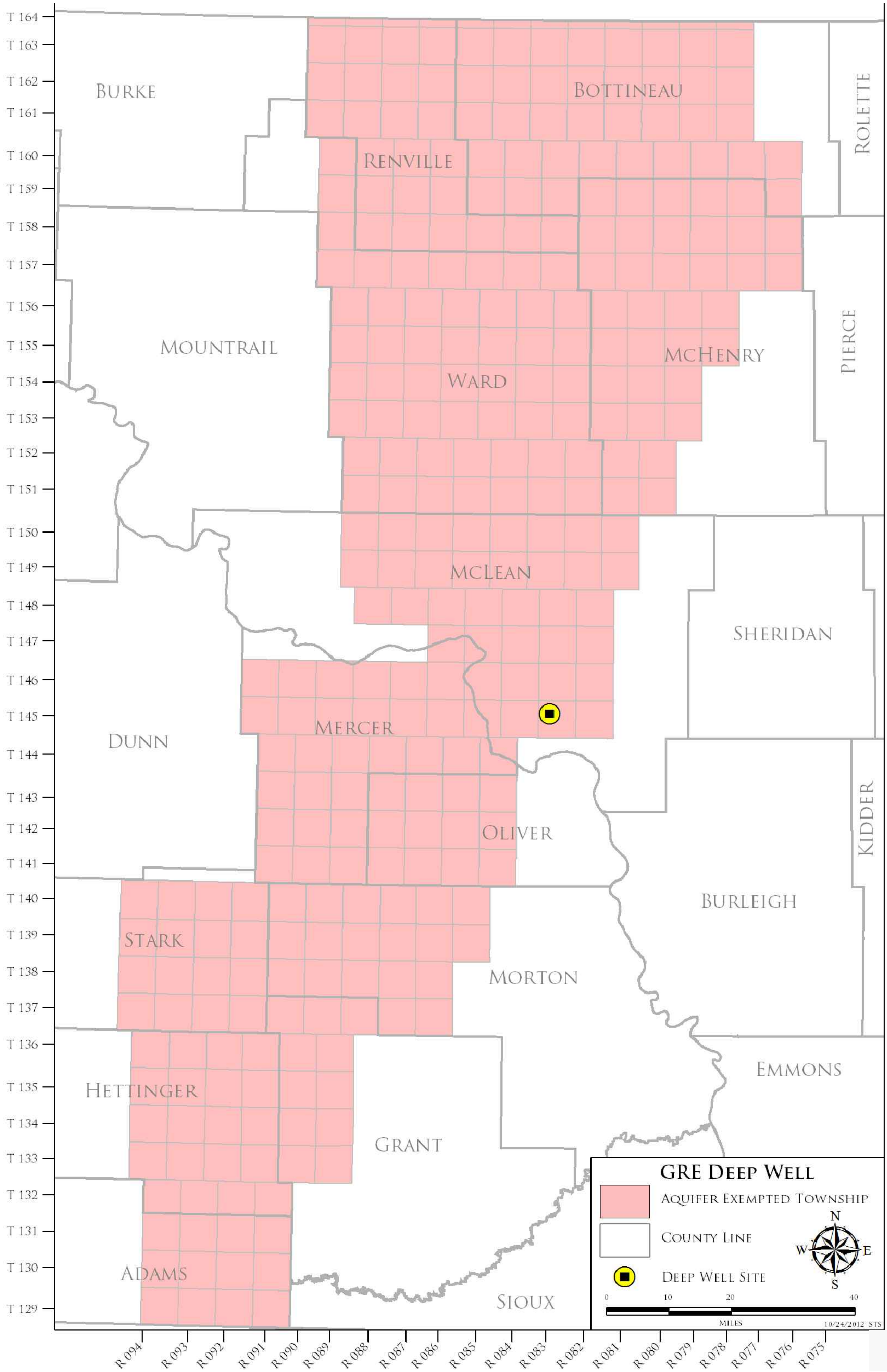

REFERENCES

1. MAP OBTAINED FROM THE NORTH DAKOTA DEPARTMENT OF HEALTH (NDDH) ON 10/24/12.

PROJECT

GREAT RIVER ENERGY
UNDERGROUND INJECTION WELL
UNDERWOOD, NORTH DAKOTA

TITLE

CLASS II DAKOTA AQUIFER EXEMPTION BOUNDARIES

Golder Associates

PROJECT No.		113-82051	FILE No.	11382051C003
DESIGN	LES	11/20/12	SCALE AS SHOWN	REV. 0
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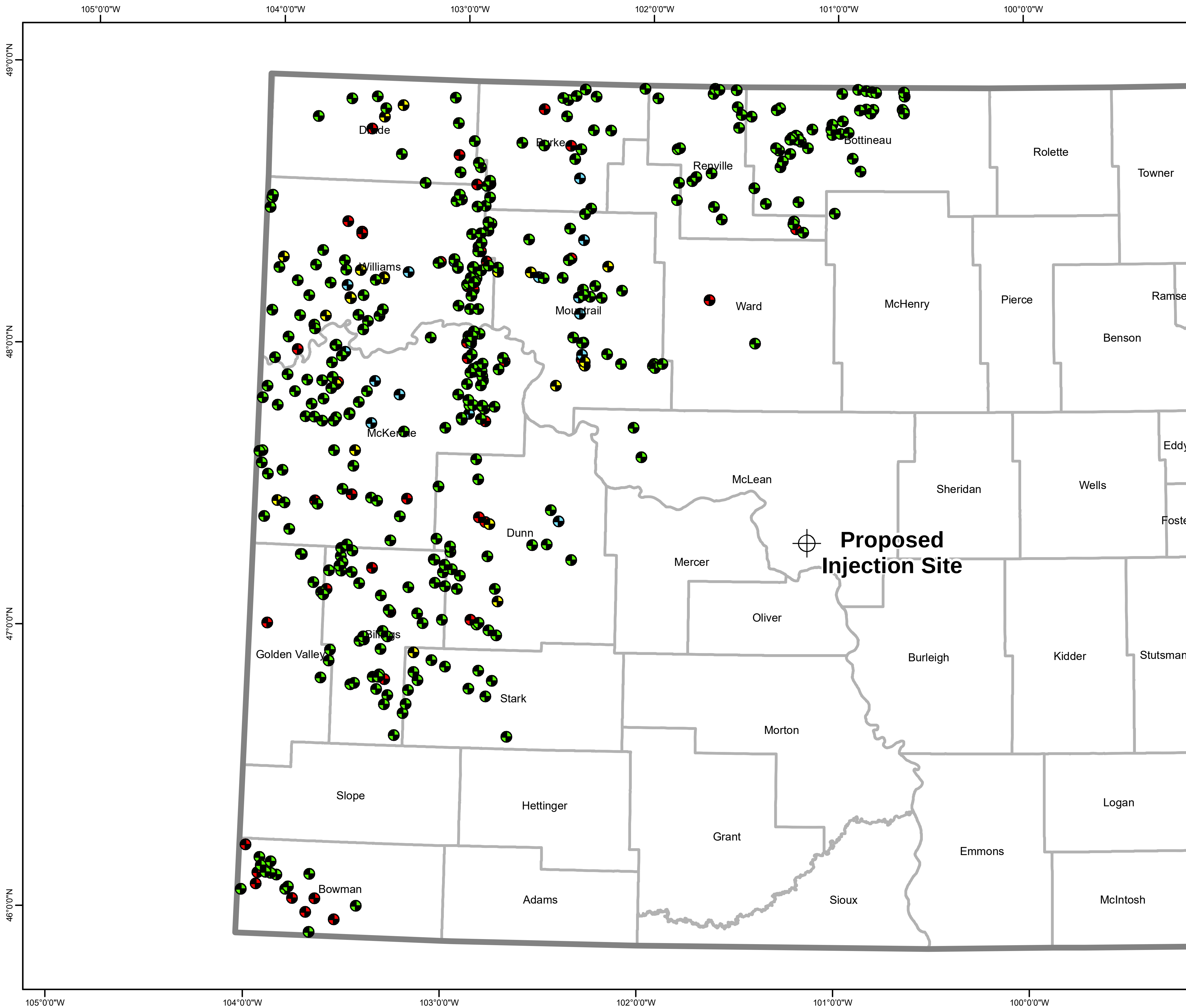

LEGEND

Proposed Injection Site

Saltwater Disposal Wells

- Active
- Inactive (missed reporting)
- Drilling
- Permitted Location to Drill

REFERENCES

Coordinate System: NAD 1983 StatePlane North Dakota South FIPS 3302 Feet.
Data obtained from North Dakota Industrial Commission, Department of Mineral Resources, Oil and Gas Division (accessed May 2012).

25 12.5 0 25 MILES

SCALE 1:1,584,000 1 INCH = 25 MILES
WHEN PRODUCED AT SIZE 11X17IN

PROJECT

GREAT RIVER ENERGY
UNDERGROUND INJECTION WELL
UNDERWOOD, NORTH DAKOTA

TITLE

NORTH DAKOTA CLASS II SALTWATER DISPOSAL WELLS

Golder Associates
Denver, Colorado

PROJECT No.		11382051	FILE No.	Fig1-5_SaltwaterDisposalWells.mxd
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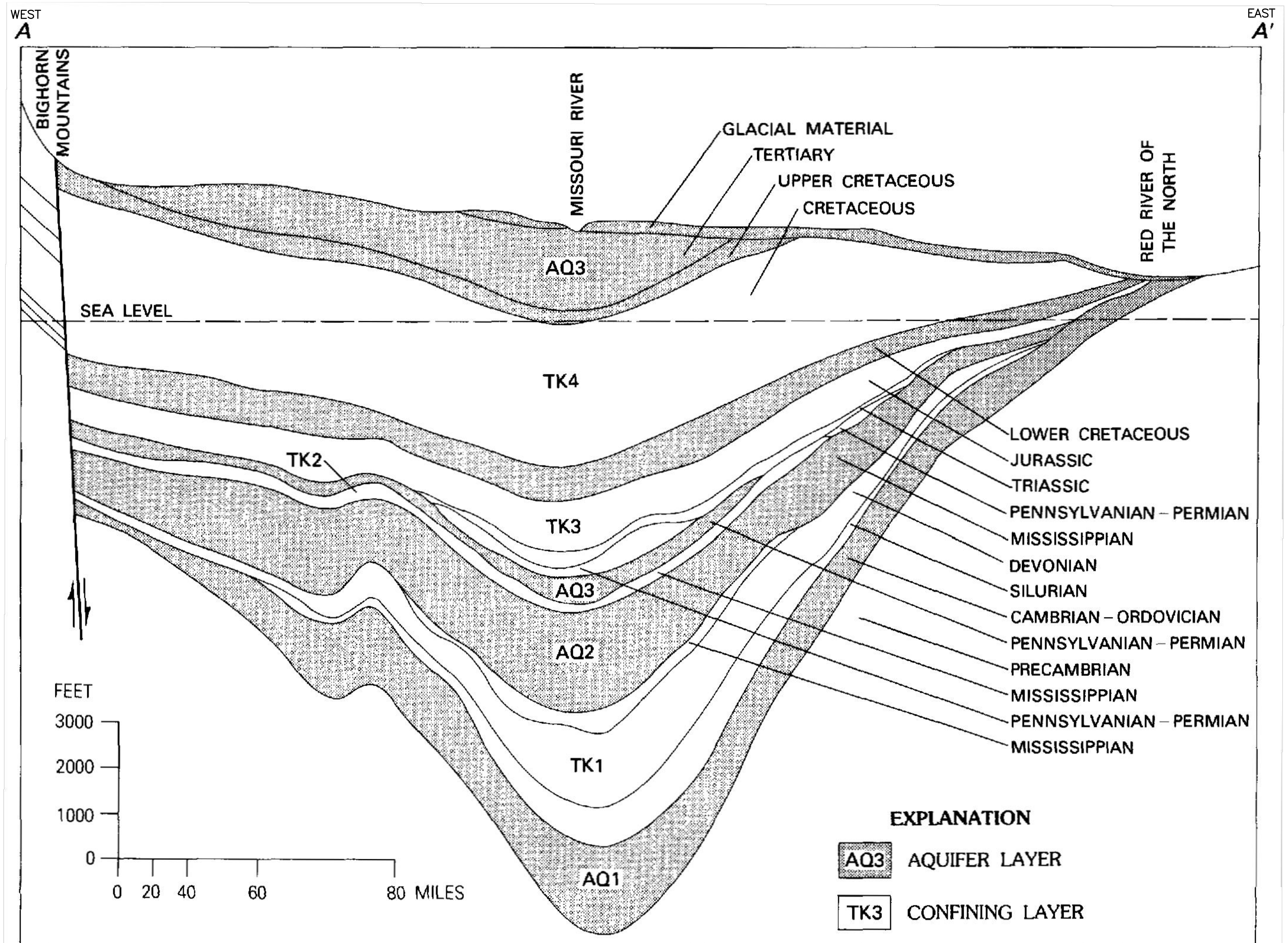

Line of section, *A-A′*, on figure 2.

FIGURE 3.—Diagrammatic cross section from ground-water recharge area to discharge area. Cross section shows relation of aquifers and confining layers in the northern Great Plains, Montana and North Dakota.

REFERENCES

1. CROSS SECTION OF REGIONAL GROUNDWATER FLOW OBTAINED FROM THE REGIONAL AQUIFER SYSTEMS ANALYSIS (DOWNEY, 1986).

PROJECT
GREAT RIVER ENERGY
UNDERGROUND INJECTION WELL
UNDERWOOD, NORTH DAKOTA

TITLE
REGIONAL HYDROGEOLOGIC STRUCTURE

Golder Associates

PROJECT No.		113-82051	FILE No.	11382051C004
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CADD	AMS	11/20/12	2-1	
CHECK	SCA	11/20/12		
REVIEW	RRJ	11/20/12		

Era	System, Series, and other subdivisions		Stratigraphic unit: Powder River Basin (Wyoming and Montana)	Stratigraphic unit: Williston Basin (Montana, North Dakota, and South Dakota)	Hydrologic unit: RASA study 5/	Hydrologic unit: This report	Principal lithology
Cenozoic	Quaternary		Alluvium	Alluvium and glacial deposits	Not included in aquifer system	Not included in aquifer system	
Cenozoic	Tertiary: Pliocene	Upper					
Cenozoic	Tertiary: Miocene	Upper					
Cenozoic	Tertiary: Oligocene	Lower	White River Formation	White River Formation or Group			
Cenozoic	Tertiary: Eocene	Lower	Wasatch Formation		Northern Great Plains aquifer system: Upper Cretaceous aquifer	Northern Great Plains aquifer system: Lower Tertiary aquifers	Sandstone, some siltstone
Cenozoic	Tertiary: Paleocene	Lower	Fort Union Formation	Fort Union Formation or Group	Upper Cretaceous aquifer	Lower Tertiary aquifers	Sandstone, some coal
Mesozoic	Cretaceous	Upper	Lance Formation	Hell Creek Formation	Upper Cretaceous aquifer	Upper Cretaceous aquifers	Sandstone, some claystone, siltstone and coal
Mesozoic	Cretaceous	Upper	Fox Hills Sandstone	Fox Hills Sandstone	Upper Cretaceous aquifer	Upper Cretaceous aquifers	Sandstone, some claystone, siltstone and coal
Mesozoic	Cretaceous	Upper	Lewis Shale	Pierre Shale	Confining layer	Confining unit	Shale, some chalk, some bentonite. Minor sandstone
Mesozoic	Cretaceous	Upper	Mesaverde Formation	Pierre Shale	Confining layer	Confining unit	Shale, some chalk, some bentonite. Minor sandstone
Mesozoic	Cretaceous	Upper	Steele Shale	Pierre Shale	Confining layer	Confining unit	Shale, some chalk, some bentonite. Minor sandstone
Mesozoic	Cretaceous	Upper	Cody Shale 1/	Niobrara Formation	Confining layer	Confining unit	Shale, some chalk, some bentonite. Minor sandstone
Mesozoic	Cretaceous	Upper	Frontier Formation	Carlile Shale	Confining layer	Confining unit	Shale, some chalk, some bentonite. Minor sandstone
Mesozoic	Cretaceous	Upper	Frontier Formation	Greenhorn Formation	Confining layer	Confining unit	Shale, some chalk, some bentonite. Minor sandstone
Mesozoic	Cretaceous	Upper	Frontier Formation	Belle Fourche Shale	Confining layer	Confining unit	Shale, some chalk, some bentonite. Minor sandstone
Mesozoic	Cretaceous	Upper	Mowry Shale	Mowry Shale	Confining layer	Confining unit	Shale
Mesozoic	Cretaceous	Lower	Muddy Sandstone	Newcastle/Dakota Sandstone 2/	Lower Cretaceous aquifer	Lower Cretaceous aquifers	Sandstone
Mesozoic	Cretaceous	Lower	Thermopolis Shale	Skull Creek Shale	Lower Cretaceous aquifer	Lower Cretaceous aquifers	Shale
Mesozoic	Cretaceous	Lower	Inyan Kara Group: Fall River Formation	Inyan Kara Group: Fall River Sandstone	Lower Cretaceous aquifer	Lower Cretaceous aquifers	Sandstone. Minor conglomerate and silty shale
Mesozoic	Cretaceous	Lower	Inyan Kara Group	Inyan Kara Group: Fuson Formation	Lower Cretaceous aquifer	Lower Cretaceous aquifers	Sandstone. Minor conglomerate and silty shale
Mesozoic	Cretaceous	Lower	Inyan Kara Group: Lakota Formation	Inyan Kara Group: Lakota Formation	Lower Cretaceous aquifer	Lower Cretaceous aquifers	Sandstone. Minor conglomerate and silty shale
Mesozoic	Jurassic		Morrison Formation	Morrison Formation	Confining layer	Confining unit	Shale and silty shale with interbedded sandstone
Mesozoic	Jurassic		Sundance Formation 3/	Swift Formation 3/	Confining layer	Confining unit	Shale and silty shale with interbedded sandstone
Mesozoic	Jurassic		Sundance Formation 3/	Rierdon Formation 3/	Confining layer	Confining unit	Shale and silty shale with interbedded sandstone
Mesozoic	Jurassic		Gypsum Spring Formation	Piper Formation 3/	Confining layer	Confining unit	Shale and limestone
Mesozoic	Triassic		Chugwater Formation		Confining layer	Confining unit	Shale and siltstone
Paleozoic	Permian		Goose Egg Formation	Spearfish Formation	Confining layer	Confining unit	Shale and siltstone
Paleozoic	Permian		Goose Egg Formation	Minnekahta Limestone	Confining layer	Confining unit	Shale and siltstone
Paleozoic	Permian			Opeche Formation	Confining layer	Confining unit	Shale and siltstone
Paleozoic	Pennsylvanian		Tensleep 4/ Sandstone; Minnelusa 4/ Formation	Amsden Formation; Minnelusa 4/ Formation	Pennsylvanian aquifer system	Confining unit	Interbedded sandstone, shale and carbonate rocks. Minor anhydrite
Paleozoic	Pennsylvanian		Amsden Formation	Tyler Formation; Minnelusa 4/ Formation	Pennsylvanian aquifer system	Confining unit	Shale and sandstone
Paleozoic	Mississippian			Big Snowy Group	Confining layer	Confining unit	Shale with some sandstone
Paleozoic	Mississippian		Madison Limestone	Madison Group: Charles Formation	Mississippian aquifer	Upper 6/ Paleozoic aquifers	Limestone, dolomite, and minor anhydrite
Paleozoic	Mississippian		Madison Limestone	Madison Group: Mission Canyon Limestone	Mississippian aquifer	Upper 6/ Paleozoic aquifers	Limestone, dolomite, and minor anhydrite
Paleozoic	Mississippian		Madison Limestone	Madison Group: Lodgepole Limestone	Mississippian aquifer	Upper 6/ Paleozoic aquifers	Limestone, dolomite, and minor anhydrite
Paleozoic	Devonian		Darby Formation and equivalents	Bakken Formation	Confining layer	Confining unit	Shale and siltstone
Paleozoic	Devonian		Darby Formation and equivalents	Three Forks Formation through Ashern Formation	Confining layer	Confining unit	Shale, shaly limestone, some evaporite beds and salt
Paleozoic	Silurian			Interlake Formation	Confining layer	Confining unit	Shaly limestone
Paleozoic	Ordovician		Bighorn Dolomite; Whitewood Dolomite	Stonewall Formation	Cambrian-Ordovician aquifer	Lower 6/ Paleozoic aquifers	Limestone, shaly limestone
Paleozoic	Ordovician		Bighorn Dolomite; Whitewood Dolomite	Red River Formation	Cambrian-Ordovician aquifer	Lower 6/ Paleozoic aquifers	Limestone and dolomite
Paleozoic	Ordovician		Harding Sandstone; Winnipeg Formation	Winnipeg Formation or Group	Cambrian-Ordovician aquifer	Lower 6/ Paleozoic aquifers	Shale, sandstone, and shaly limestone
Paleozoic	Cambrian		Gallatin Limestone	Deadwood Formation	Cambrian-Ordovician aquifer	Lower 6/ Paleozoic aquifers	Sandstone, dolomitic limestone, and shale
Paleozoic	Cambrian		Gros Ventre Formation	Deadwood Formation	Cambrian-Ordovician aquifer	Lower 6/ Paleozoic aquifers	Sandstone, dolomitic limestone, and shale
Paleozoic	Cambrian		Flathead Sandstone	Deadwood Formation	Cambrian-Ordovician aquifer	Lower 6/ Paleozoic aquifers	Sandstone

1/ Equivalent in part to Judith River Formation and Eagle Sandstone in Central Montana
2/ Locally extends into Upper Cretaceous
3/ Included in Lower Cretaceous aquifers of this report, where permeable
4/ Included in Upper Paleozoic aquifers of this report, where permeable
5/ Downey and Dinwiddie, 1988
6/ Not differentiated in figure 49

Figure 50. Numerous geologic units are part of the Northern Great Plains aquifer system, but only beds of sandstone and carbonate rocks form aquifers. The gray areas represent missing rocks.

Modified from:

Downey, J.S., and Dinwiddie, G.A., 1988, The regional aquifer system underlying the Northern Great Plains in parts of Montana, North Dakota, South Dakota, and Wyoming—Summary: U.S. Geological Survey Professional Paper 1402–A, 64 p.

Love, J.D., Christiansen, A.C., and Ver Ploeg, A.J., 1993, Stratigraphic chart showing Phanerozoic nomenclature for the State of Wyoming: Geological Survey of Wyoming Map Series 41, 1 sheet.

REFERENCES

1. STRATIGRAPHIC COLUMN OBTAINED FROM THE GROUND WATER ATLAS OF THE UNITED STATES (WHITEHEAD, 1996).

PROJECT
GREAT RIVER ENERGY
UNDERGROUND INJECTION WELL
UNDERWOOD, NORTH DAKOTA

TITLE
REGIONAL STRATIGRAPHIC COLUMN

Golder Associates

PROJECT No.		113-82051	FILE No.	11382051C005
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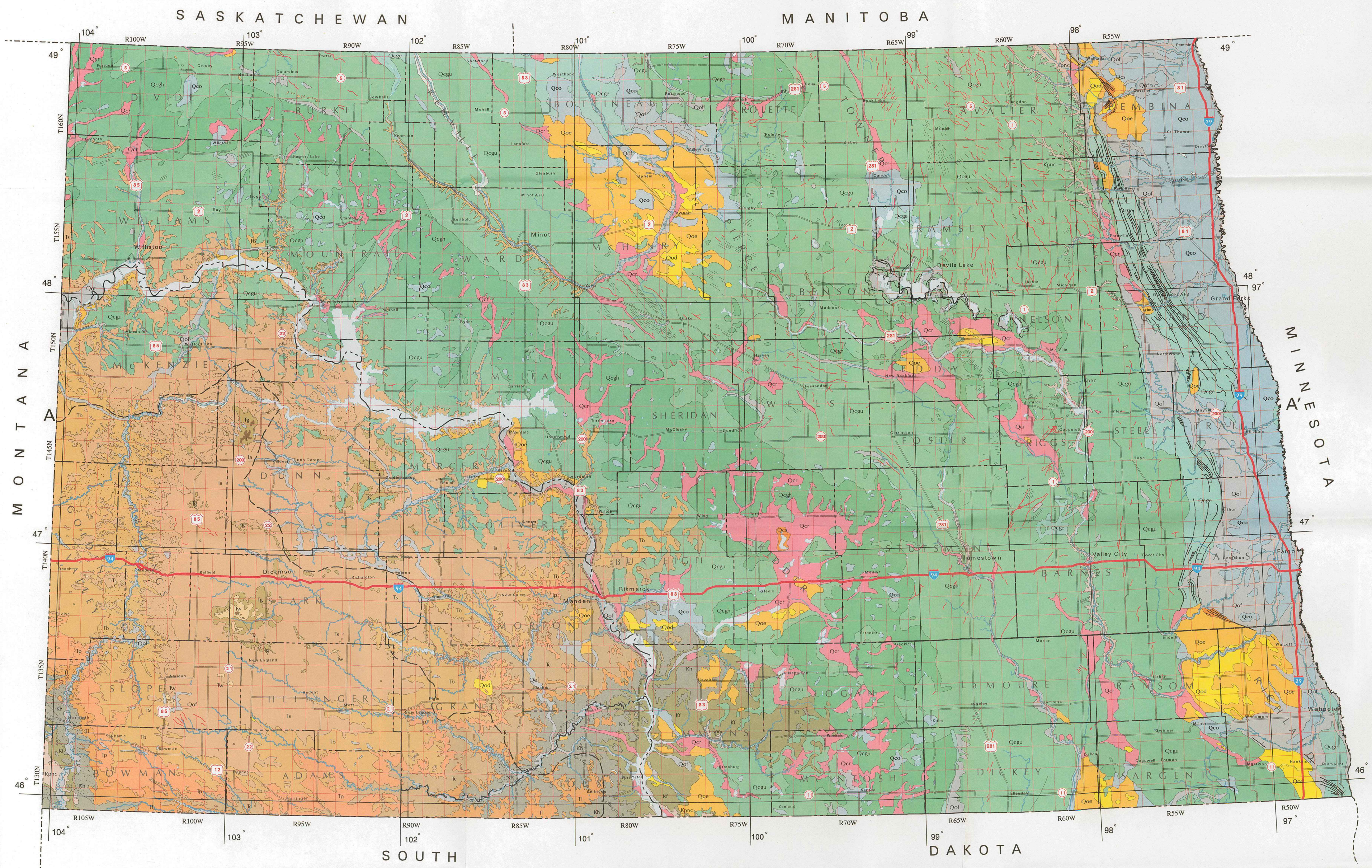
Educational Series 26
Plate I

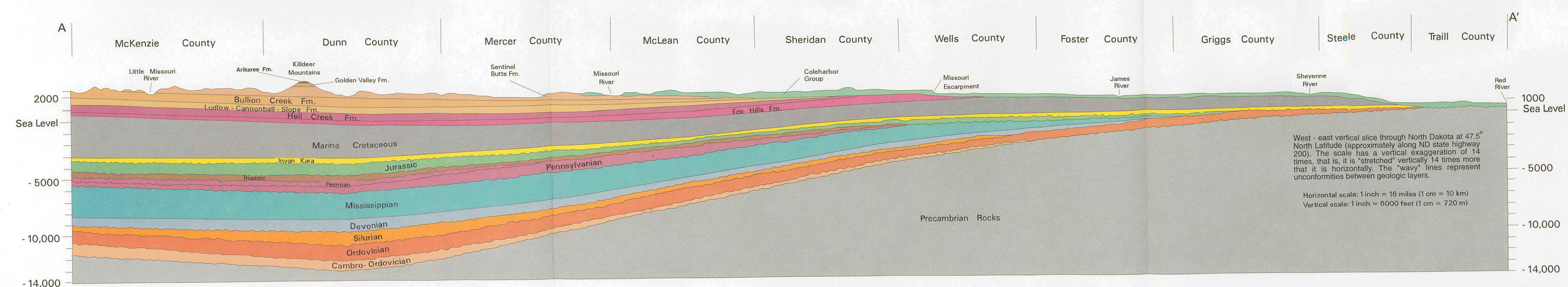
Geologic Map of North Dakota

John P. Bluemle

2000

North Dakota Geological Survey
John P. Bluemle, State Geologist





MAP EXPLANATION

The geologic designations used here are "coded" thus: units designated with a capital "Q" are of Quaternary age (see text). Units designated by a capital "T" are Tertiary in age, and units designated "K" are Cretaceous in age.

Each geologic unit also includes several lower-case letter designations; an "o" immediately following the Q means the unit is part of the Oahe Formation. A "c" means it is part of the Coleharbor Group. A "b" following a capital "T" means the unit is the Tertiary-age Bullion Creek Formation, etc.

Following the "o" or "c" are one or more additional lower-case letters. These are explained in the description for that unit. For example, Qoe is material that is of eolian origin (wind-blown); Qof is fluvial in origin (deposited by water).

In some places such as in badlands and in hilly areas covered by glacial deposits, the geologic materials indicated on the map may be seen at the surface of the ground. In many level areas, however, soil completely covers the indicated geologic materials to a depth of several feet.

QUATERNARY (Holocene)

Qof — Oahe Formation fluvial (water-lain) deposits. Includes dark, obscurely bedded clay and silt and cross-bedded sand (river sediment), dark, obscurely bedded clay and silt (pond or slough sediment), and water-lain terrace, fan, or pediment deposits (sand, gravel and cobbles).

Qod — Oahe Formation eolian (wind-blown) dune deposits; knobby topography consisting of inactive transverse or longitudinal dunes and recent blowouts.

Qoe — Oahe Formation eolian (wind-blown) deposits. Areas mantled with fine, wind-blown silt deposits (loess). Includes interbedded paleosols.

ls — Landslides.

QUATERNARY (Pleistocene)

Qcs — Coleharbor Group shoreline deposits. Includes well-sorted sand and gravel of beach ridges; best-developed along the former shore lines of glacial Lake Agassiz.

Qco — Coleharbor Group offshore lake deposits. Includes flat-bedded, laminated silt and clay of glacier-dammed lakes. May exist as pro-glacial lake deposits (such as Lake Agassiz), ice-walled or collapsed supraglacial lake deposits, or eroded lake deposits along valley walls.

Qcr — Coleharbor Group river deposits. Includes moderately well-sorted, cross-bedded sand and plane-bedded gravel of melt-water and other rivers. May exist as flat-bedded to gently sloping plains and terraces or faulted and contorted supraglacial sediment with hummocky topography (collapsed river sediment).

Qcgu — Coleharbor Group glacial deposits. Includes unbedded, unsorted mixture of clay, silt, sand, and pebbles (till), plus a few cobbles and boulders. Exists mainly as gently undulating to undulating topography and consists of a variety of landforms.

Qcgh — Coleharbor Group glacial deposits. Similar composition and texture as Qcgu. Exists mainly as rolling to hilly topography and consists of a variety of stagnant - glacier landforms.

Qcge — Coleharbor Group glacial deposits. Similar composition and texture as Qcgu and Qcgh. Exists mainly as stream- or wave-eroded surfaces. Topography may be undulating to hilly.

TERTIARY

Ta — Arikaree Formation of late Oligocene to Miocene age. River and lake sediment consisting of concretionary, cross-bedded, calcareous sandstones, siltstones, claystones, carbonates and tuffs. Forms a resistant caprock on the Killdeer Mountains.

Tw — White River Group of Oligocene age. River and lake sediment. Includes the Brule Formation: pinkish siltstone, clay, and sand; and Chadron Formation: light-colored sand with quartzite and porphyry pebbles, overlain by dark clay.

Tg — Golden Valley Formation of Eocene and Paleocene age. Upper member: fluvial yellow-brown, micaceous sandstone, sand, silt, and clay; Lower member: white or yellow clay, silt, and sand (a weathering zone). This unit includes some undifferentiated Upper and Middle Tertiary fluvial or lacustrine sandstone or limestone that occurs as butte caprock.

Ts — Sentinel Butte Formation of Paleocene age. River, lake, and swamp sediments. Consists of gray-brown silt, sand, clay, sandstone, and lignite.

Tb — Bullion Creek Formation of Paleocene age. River, lake, and swamp sediments. Consists of yellow-brown silt, sand, clay, sandstone, and lignite.

Tp — Slope Formation of Paleocene age. River, lake, and swamp sediment. Consists of gray-brown silt, sand, clay, sandstone, and lignite.

Tc — Cannonball Formation of Paleocene age. Marine shoreline and offshore sediment. Consists of olive-brown sand, shale, and sandstone.

Tl — Ludlow Formation of Paleocene age. River, lake, and swamp deposits. Consists of gray-brown and yellow-brown silt, sand, sandstone, clay, and lignite.

UPPER CRETACEOUS

Kh — Hell Creek Formation. River sediment. Gray sand, silt, clay, and sandstone.

Kf — Fox Hills Formation. Marine shoreline and offshore sediment. Olive-brown sand, shale, and sandstone.

Kpnc — Pierre, Niobrara, Carlile, and Greenhorn Formations (undifferentiated). Marine offshore sediment. Pierre: dark-gray shale; Niobrara: light-brown to dark gray calcareous shale; Carlile: dark gray shale; Greenhorn: dark-gray calcareous shale with white specks.

OTHER FEATURES

Hydrologic Features. Light fill for lakes, darker outline for shorelines and rivers.

Eskers. Long, narrow, sinuous ridges of stratified glacier sediment, usually gravel. Deposited by a stream that flowed on, within, or beneath the glacial ice.

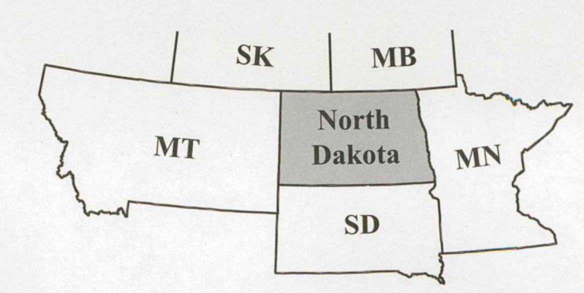
Drumlin Ridges.

Beach Ridges.

Maximum Extent of Glaciation.

BadlandsTopography.

The North Dakota Geological Survey compiled this map according to conventional cartographic standards, using what is thought to be the most reliable information available. The North Dakota Geological Survey does not guarantee freedom from errors or inaccuracies and disclaims any legal responsibility or liability for interpretations made from the map, or decisions based thereon. The user should consult other publications or experts before making any interpreations based on this information.



Cartographic Compiliation: R.P. Waldkirch

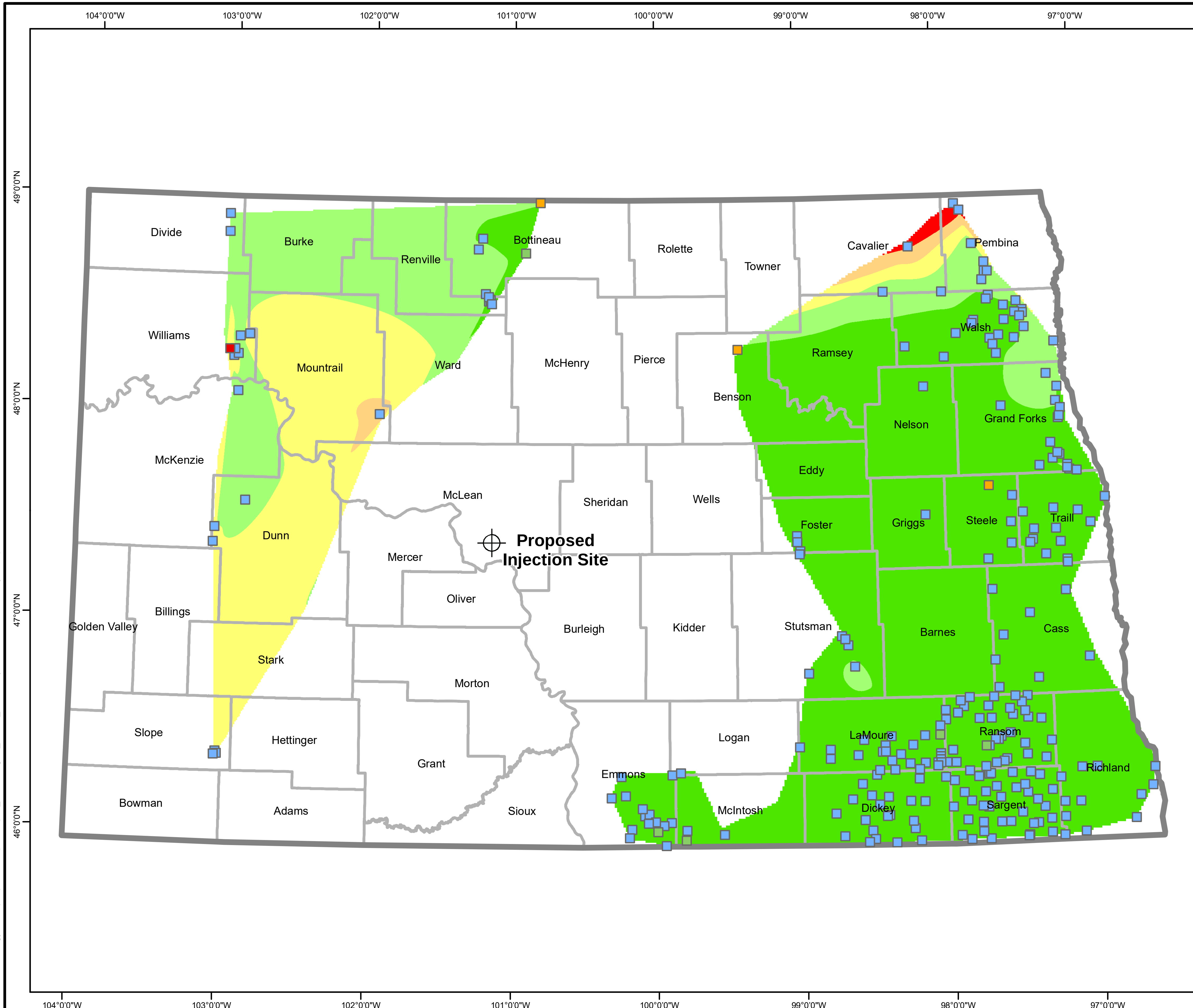
Golder Associates

PROJECT
GREAT RIVER ENERGY
UNDERGROUND INJECTION WELL
UNDERWOOD, NORTH DAKOTA

TITLE
GEOLOGIC PLAN AND
PROFILE OF NORTH DAKOTA

PROJECT No.		113-82051
FILE No.		11382051C004
REV. 0	SCALE	AS SHOWN
DESIGN	AMS	11/20/12
CADD	AMS	11/20/12
CHECK	SCA	11/20/12
REVIEW	RRJ	11/20/12

2-3



LEGEND

Proposed Injection Site

Dakota Wells

Number of Data Points

- 1
- 2
- 3
- 4

Inferred TDS Concentration

mg/L

- 994 - 5,000
- 5,001 - 10,000
- 10,001 - 15,000
- 15,001 - 20,000
- > 20,000

REFERENCES

Coordinate System: NAD 1983 StatePlane North Dakota South FIPS 3302 Feet.

Data obtained from North Dakota State Water Commission county groundwater studies and the North Dakota Industrial Commission, Oil and Gas Division (accessed February 2012).

175,000 87,500 0 175,000 FEET

SCALE 1:2,100,000 1 INCH = 175,000 FEET

WHEN PRODUCED AT SIZE 11X17IN

PROJECT

GREAT RIVER ENERGY
UNDERGROUND INJECTION WELL
UNDERWOOD, NORTH DAKOTA

TITLE

DAKOTA TDS CONCENTRATIONS

Golder Associates
Denver, Colorado

PROJECT No.		11382051	FILE No. Fig2-4_Dakota_TDS.mxd
DESIGN	LS	11/29/2012	SCALE AS SHOWN REV 0
GIS	KJC	11/29/2012	2-4
CHECK	SCA	11/29/2012	
REVIEW	RRJ	11/29/2012	

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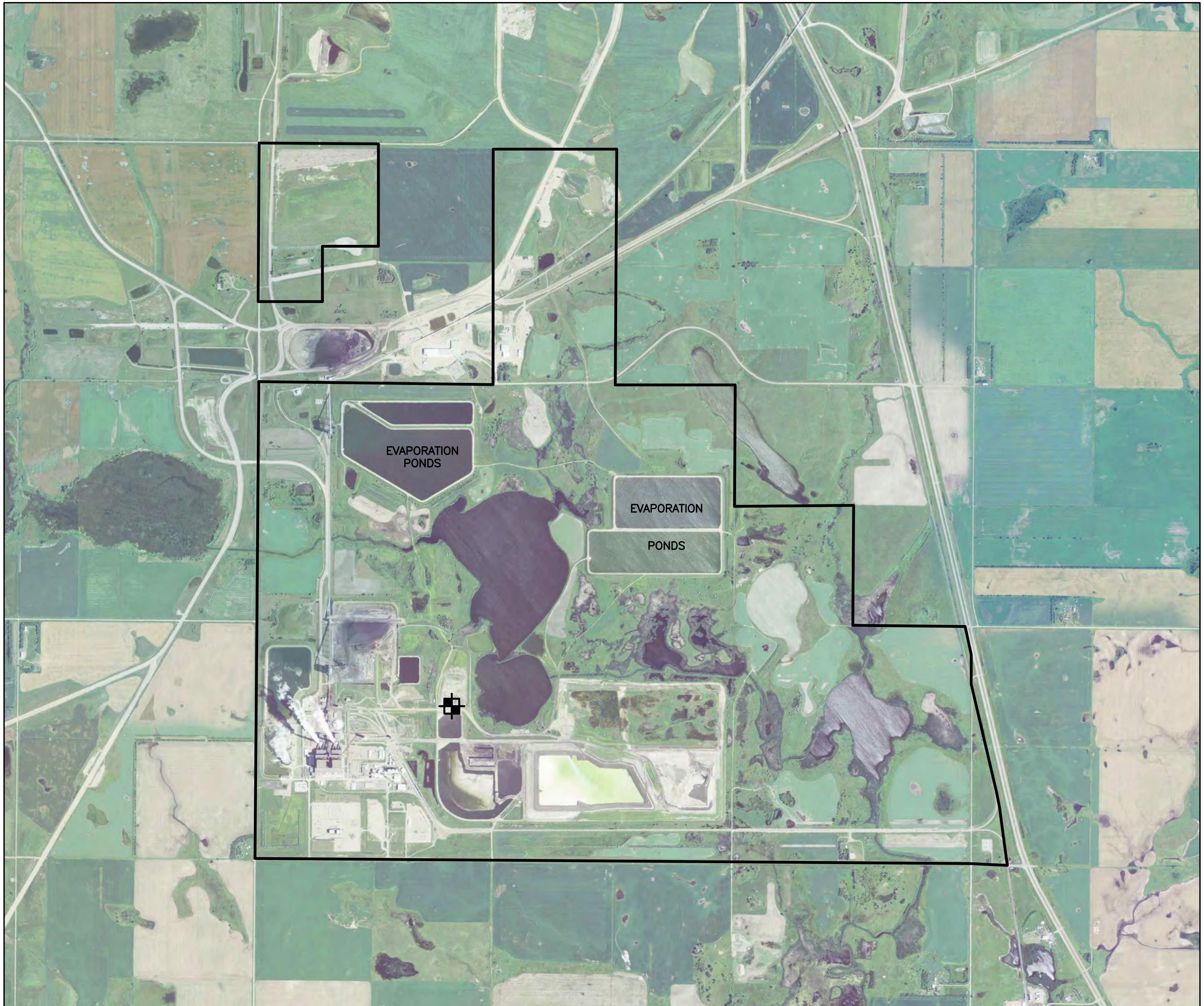

LEGEND

GRE PROPERTY BOUNDARIES/PROPOSED BOUNDARIES OF AQUIFER EXEMPTION

PROPOSED INJECTION SITE

REFERENCES

1. AERIAL IMAGE OBTAINED FROM MICROSOFT CORPORATION (2010).
2. GRE PROPERTY BOUNDARIES TAKEN FROM PLAT OBTAINED FROM THE MCLEAN COUNTY TAX EQUALIZATION OFFICE IN FEBRUARY 2012.
3. BOUNDARIES SHOWN AMOUNT TO 6.1 SQUARE MILES OR 3,900 ACRES IN AREA.

2200 0 2200
1" = 2,200' FEET

PROJECT
GREAT RIVER ENERGY
UNDERGROUND INJECTION WELL
UNDERWOOD, NORTH DAKOTA

TITLE
PROPOSED AREA OF AQUIFER EXEMPTION

Golder Associates

PROJECT No.	113-82051		FILE No.	11382051C006
DESIGN	LES	11/20/12	SCALE AS SHOWN	REV. 0
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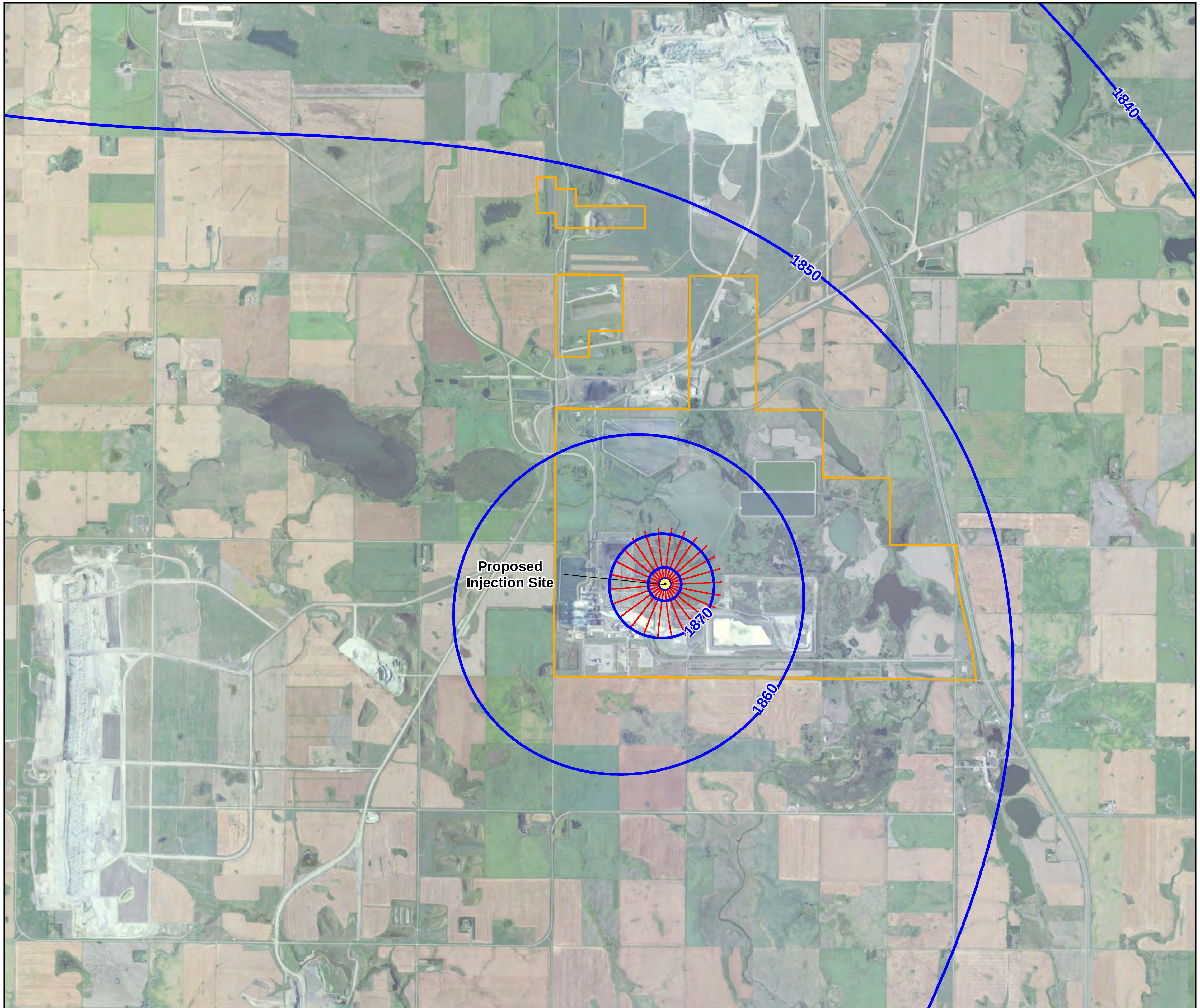
CHECK	SCA	11/20/12		
REVIEW	RRJ	11/20/12		



LEGEND

- Proposed Injection Site
- Modeled Head after 50 Years of Injection (10-ft contour interval)
- Modeled Particle Traces (50 years)
- Great River Energy Property Boundary

NOTES

1. BASE CASE SIMULATION WITH BEST ESTIMATES OF FORMATION PROPERTIES.
2. INJECTION INTERVAL IS APPROXIMATELY 3,550-3,900 FEET BELOW GROUND SURFACE.
3. THE MAXIMUM PRESSURE INCREASE AT THE WELL AFTER 50 YEARS OF INJECTION (500 GPM) IS APPROXIMATELY 141 FEET (61 PSI).

REFERENCES

COORDINATE SYSTEM: NAD 1983 STATEPLANE NORTH DAKOTA NORTH FIPS 3301 FEET.
AERIAL IMAGERY: MICROSOFT 2010.
PARTICLE TRACES AND HEAD/PRESSURE INCREASE CONTOURS MODELED IN AQUIFERWIN32.

0 4,000 8,000
FEET
1 INCH = 4,000 FEET
IF PRINTED AT 11 X 17 IN

PROJECT
GREAT RIVER ENERGY
UNDERGROUND INJECTION WELL
UNDERWOOD, NORTH DAKOTA

TITLE
50-YEAR HEAD DISTRIBUTION AND PARTICLE TRACES IN THE DAKOTA AQUIFER

Golder Associates

PROJECT No. 113-82051			FILE No. Fig2-6_DakotaBaseTrace.mxd
DESIGN	LES	11/30/2012	SCALE AS SHOWN REV 0
GIS	KJC	11/30/2012	2-6
CHECK	SCA	11/30/2012	
REVIEW	RRJ	11/30/2012	

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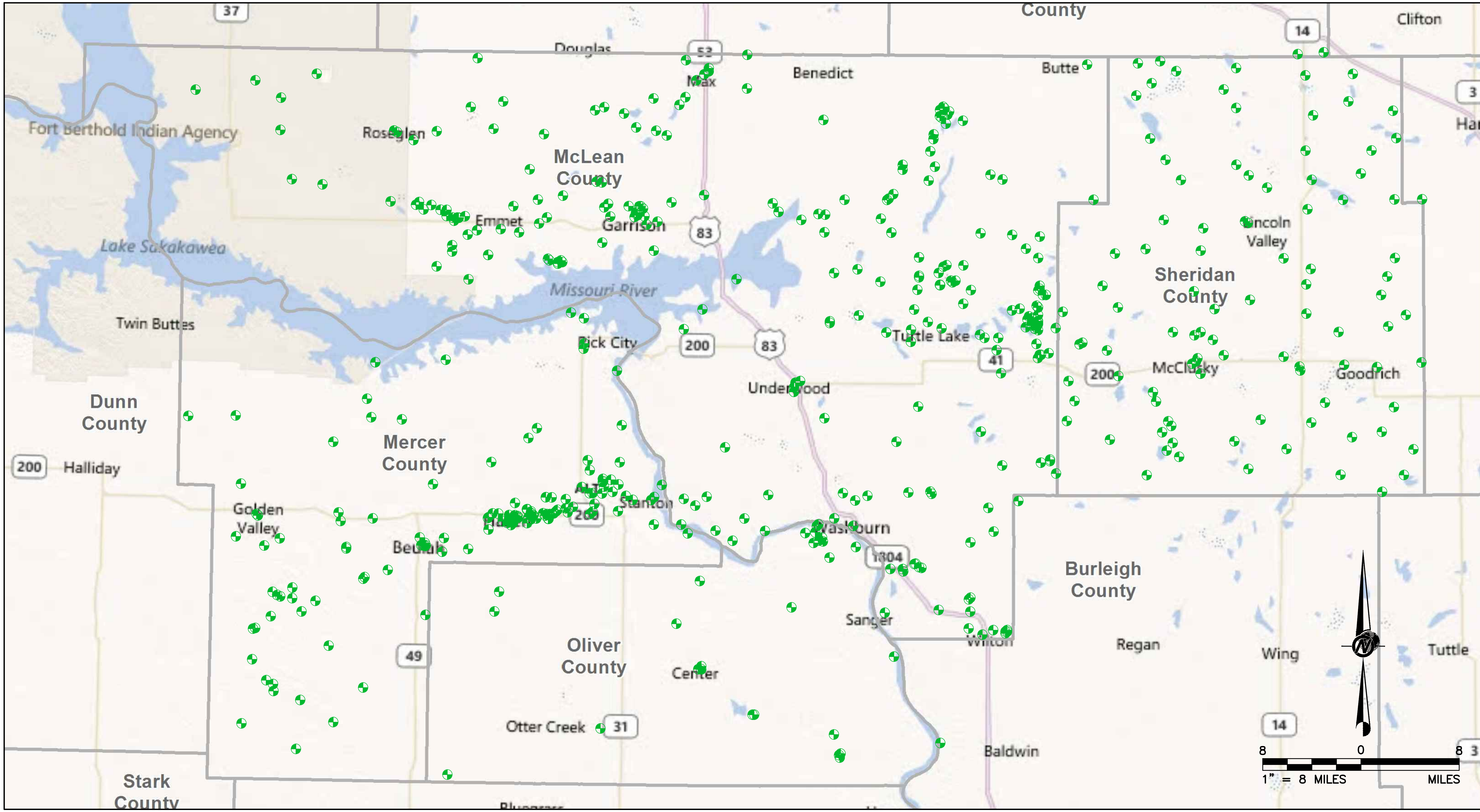

LEGEND

ACTIVE FRESHWATER WELL

REFERENCES

1. LOCATION OF ACTIVE WATER SUPPLY WELLS OBTAINED FROM THE NORTH DAKOTA STATE WATER COMMISSION, ACCESSED SEPTEMBER 2012.
2. BACKGROUND IMAGERY PROVIDED BY ESRI, BING MAPS, (C) 2012 MICROSOFT CORPORATION AND ITS DATA SUPPLIERS.

PROJECT

GREAT RIVER ENERGY
UNDERGROUND INJECTION WELL
UNDERWOOD, NORTH DAKOTA

TITLE

WATER WELLS IN MCLEAN, MERCER, OLIVER AND SHERIDAN COUNTIES

Golder Associates

PROJECT No.		113-82051	FILE No.	11382051C007
DESIGN	LES	11/20/12	SCALE AS SHOWN	REV. 0
CADD	LES	11/20/12	3-1	
CHECK	SCA	11/20/12		
REVIEW	RRJ	11/20/12		

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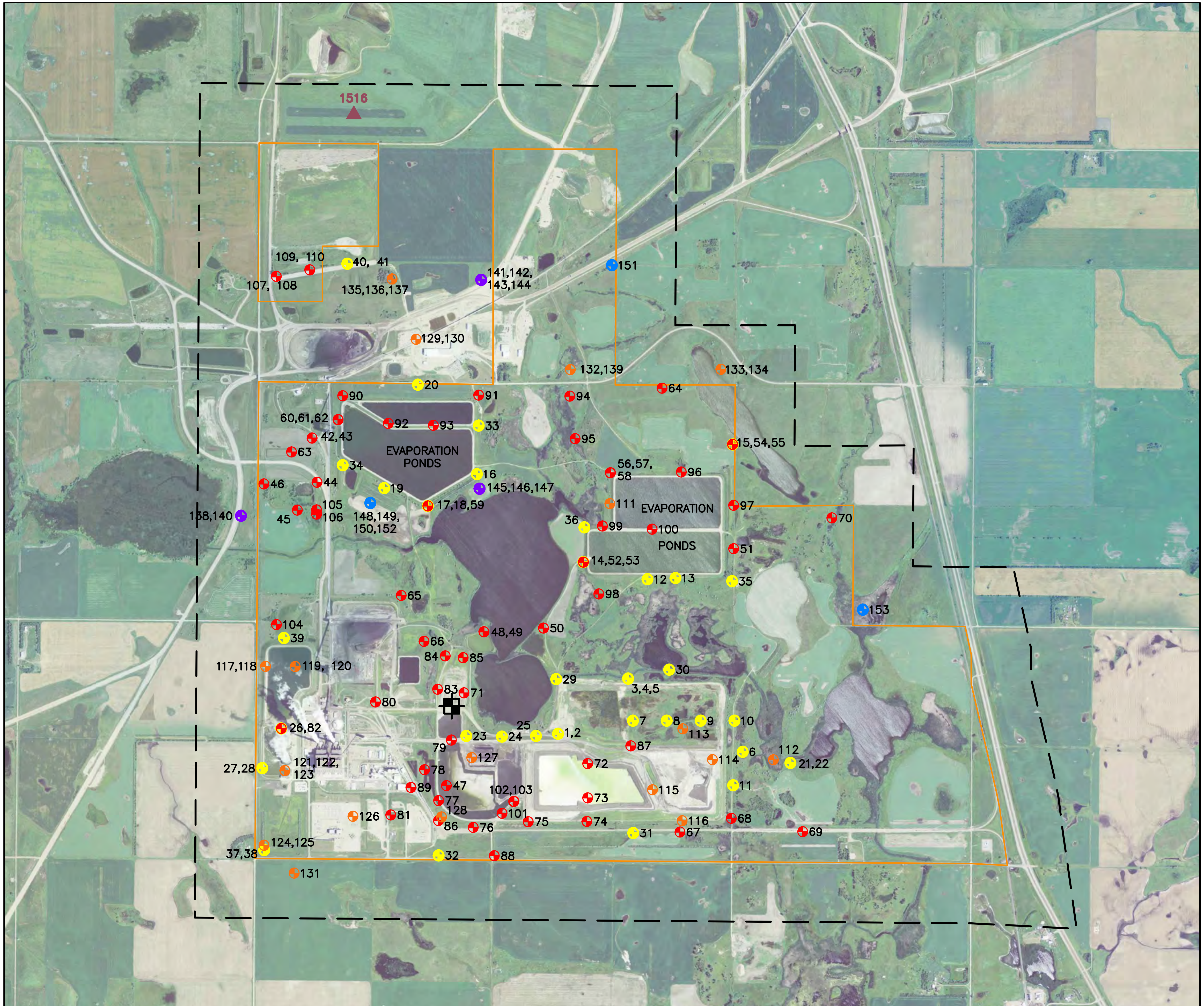

LEGEND

- ACTIVE GRE MONITORING WELL
- ABANDONED GRE MONITORING WELL
- MONITORING WELL (STATUS UNKNOWN)
- OBSERVATION WELL
- OBSERVATION WELL (PLUGGED)
- OBSERVATION WELL (DESTROYED)
- DOMESTIC WELL
- INDUSTRIAL WELL
- STOCK WELL
- TEST HOLE
- ABANDONED OIL AND GAS WELLS
- BUFFER ZONE (¼ MILE SURROUNDING PROPOSED BOUNDARIES OF AQUIFER EXEMPTION)
- GRE PROPERTY BOUNDARIES/PROPOSED BOUNDARIES OF AQUIFER EXEMPTION
- PROPOSED INJECTION SITE

REFERENCES

1. AERIAL IMAGE OBTAINED FROM MICROSOFT CORPORATION (2010).
2. GRE PROPERTY BOUNDARIES TAKEN FROM PLAT OBTAINED FROM THE MCLEAN COUNTY TAX EQUALIZATION OFFICE IN FEBRUARY 2012.
3. GRE ACTIVE AND ABANDONED WELL RECORDS AND LOCATIONS OBTAINED FROM GREAT RIVER ENERGY.
4. ADDITIONAL WELL RECORDS AND LOCATIONS OBTAINED FROM THE NORTH DAKOTA STATE WATER COMMISSION WEBSITE IN FEBRUARY 2012.
5. THE WELL NUMBERING SCHEME WAS DEVELOPED SPECIFICALLY FOR THE UNDERGROUND INJECTION WELL PERMIT APPLICATION (MARCH 2012). SEE REFERENCE TABLE 1–2 IN THE PERMIT APPLICATION FOR DETAILS ON INDIVIDUAL WELLS.

N

2200 0 2200

1" = 2,200' FEET

PROJECT

GREAT RIVER ENERGY
UNDERGROUND INJECTION WELL
UNDERWOOD, NORTH DAKOTA

TITLE

WELLS NEAR THE PROPOSED EXEMPTION AREA

Golder Associates

PROJECT No.	113–82051		FILE No.	11382051C008
DESIGN	LES	11/20/12	SCALE AS SHOWN	REV. 0
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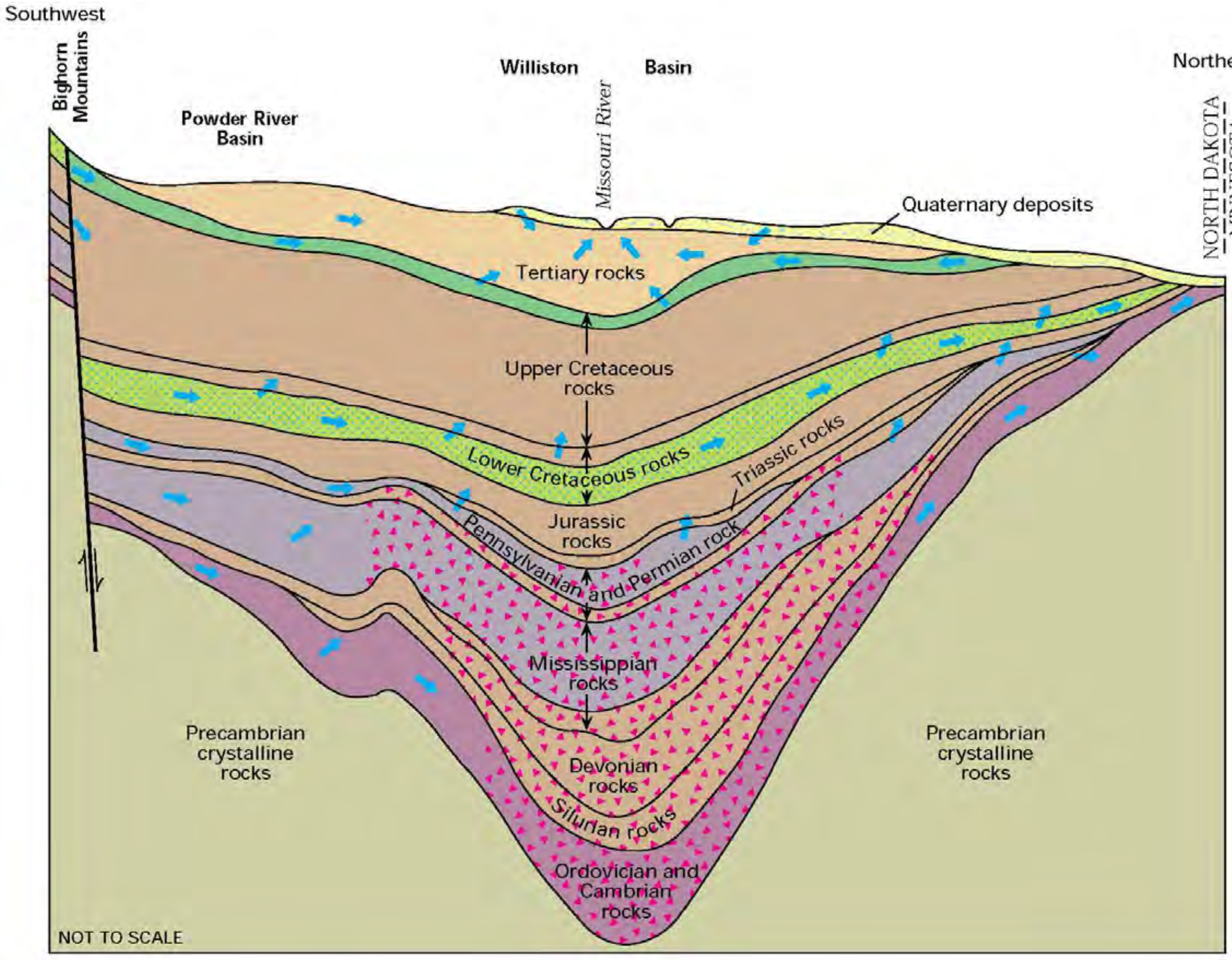
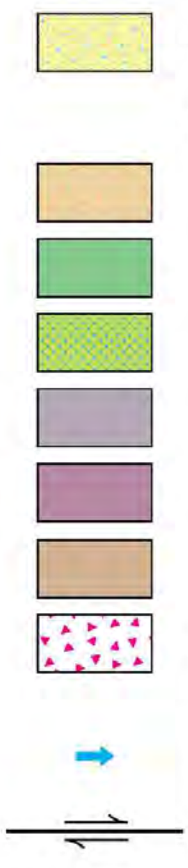
CHECK	SCA	11/20/12		3-2
REVIEW	RRJ	11/20/12		



Modified from Downey, 1984, Geohydrology of the Madison and associated aquifers in parts of Montana, North Dakota, South Dakota, and Wyoming: U.S. Geological Survey Professional Paper 1273–G, 47 p.

Figure 52. A diagrammatic section shows that regional ground-water movement in the deep, confined aquifers is northeast-ward from aquifer outcrop areas through the Powder River and the Williston Basins to discharge areas in eastern North Dakota. Water discharges upward from deep aquifers that have high artesian pressure to shallow aquifers that have lower pressure.



REFERENCES

1. CROSS SECTION OF REGIONAL GROUNDWATER FLOW OBTAINED FROM THE GROUND WATER ATLAS OF THE UNITED STATES (WHITEHEAD, 1996).

PROJECT
GREAT RIVER ENERGY
UNDERGROUND INJECTION WELL
UNDERWOOD, NORTH DAKOTA

TITLE
CROSS SECTION OF REGIONAL GROUNDWATER FLOW IN NORTH DAKOTA

PROJECT No.		113-82051	FILE No.	11382051C009
DESIGN	AMS	11/20/12	SCALE N/A	REV. 0
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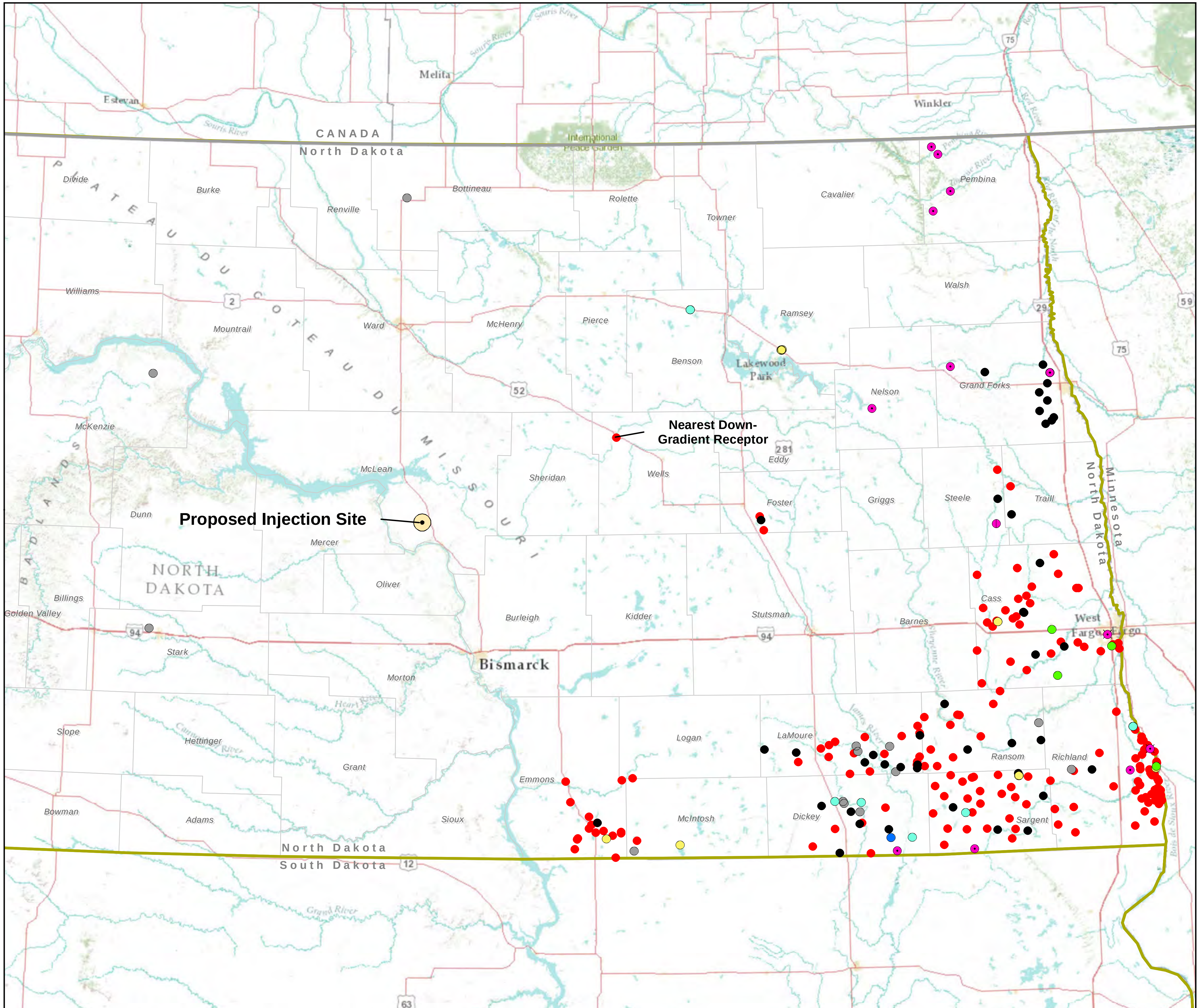
CHECK	SCA	11/20/12		3-3
REVIEW	RRJ	11/20/12		

Golder Associates

Drawing File: N:\11\113-82051_C (AQUIFER EXEMPTION)\ 11382051C009.dwg | Layout: 3-3 | Modified: Nov 29, 2012 08:41 LSeabury | Plotted: 11/29/12 8:42am LSeabury



LEGEND

- Domestic Well
- Industrial Well
- Irrigation Well
- Municipal Well
- Observation Well
- Observation Well - Plugged
- Observation Well - Recorder
- Production Well
- Stock Well
- Unknown

REFERENCES

COORDINATE SYSTEM: GCS WGS 1984.
WELLS: NORTH DAKOTA STATE WATER COMMISSION.
TOPOGRAPHIC BASEMAP: ESRI.

0 30 60
MILES
1 in = 30 miles
IF PRINTED AT 11 X 17 IN

PROJECT
GREAT RIVER ENERGY
UNDERGROUND INJECTION WELL
UNDERWOOD, NORTH DAKOTA

TITLE
DAKOTA AQUIFER WELLS

PROJECT No. 113-82051			FILE No.	Fig3-4_ND_wells.mxd
DESIGN	LES	11/29/2012	SCALE AS SHOWN	REV 0
GIS	KJC	11/29/2012	3-4	
CHECK	SCA	11/29/2012		
REVIEW	RRJ	11/29/2012		

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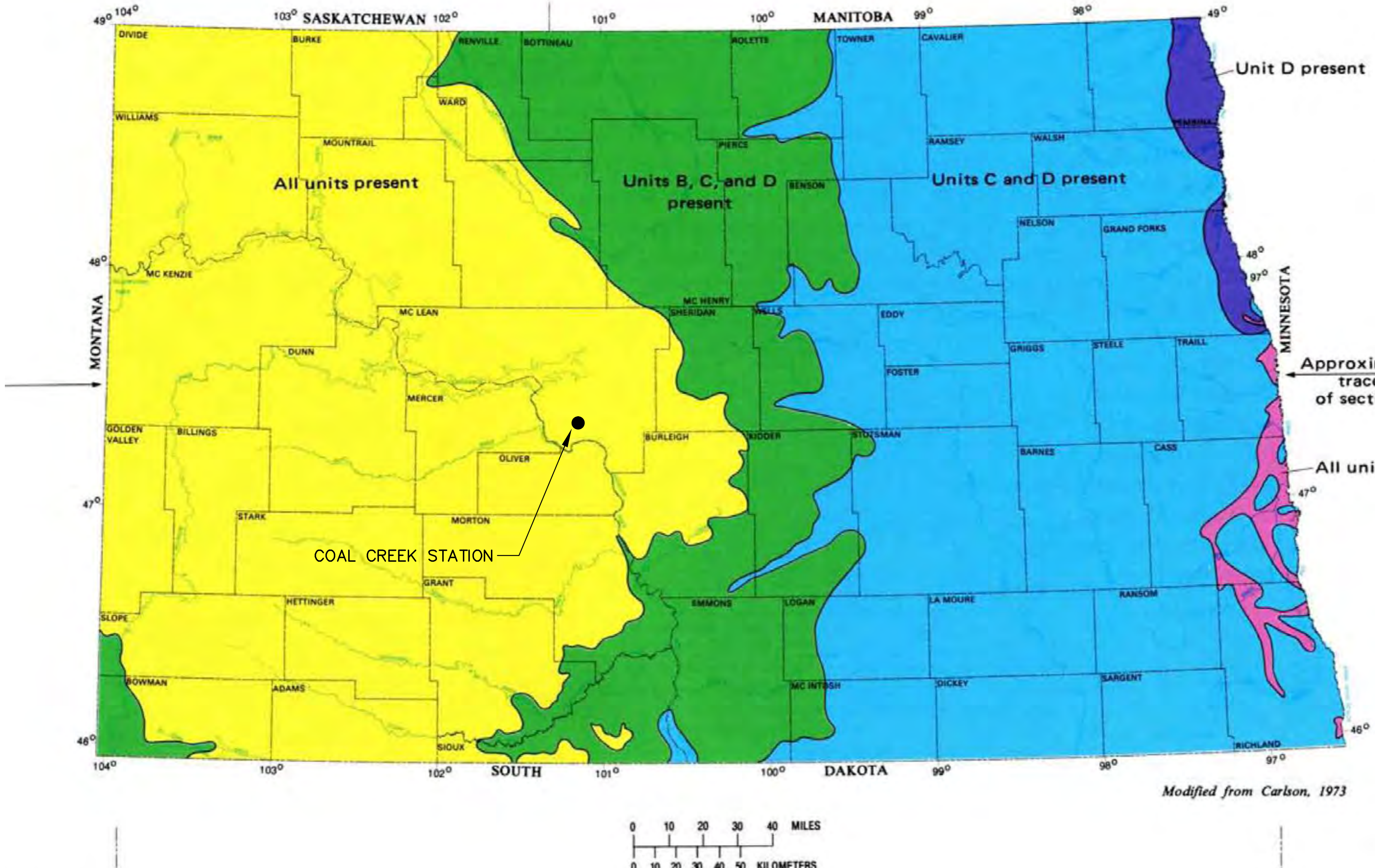
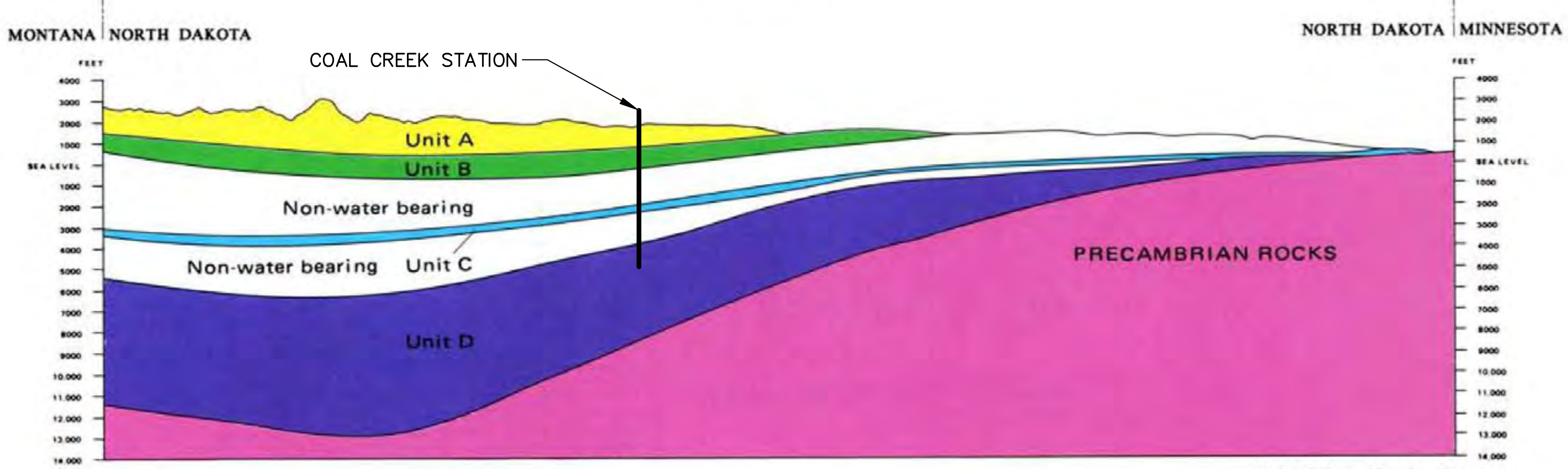


Figure 8. Location and depths of bedrock aquifer units A, B, C, and D. More bedrock aquifers are available in western North Dakota than in the eastern part. However, depth to aquifers increases towards the west. Color on map represents uppermost unit.



LEGEND

- UNIT A: FORT UNION FORMATION
- UNIT B: LOWER PART OF HELL CREEK FORMATION AND FOX HILLS SANDSTONE
- UNIT C: DAKOTA SANDSTONE
- UNIT D: PALEOZOIC ROCKS (INCLUDING MINNELUSA AND MADISON GROUPS)
- ALL UNITS ABSENT

REFERENCES

1. FIGURE OBTAINED FROM "GUIDE TO NORTH DAKOTA'S GROUND-WATER RESOURCES," USGS WATER-SUPPLY PAPER 2236 (PAULSON, 1983).

PROJECT
GREAT RIVER ENERGY
UNDERGROUND INJECTION WELL
UNDERWOOD, NORTH DAKOTA

TITLE
AQUIFER EXTENTS IN NORTH DAKOTA

Golder Associates

PROJECT No.		113-82051	FILE No.	11382051C010
DESIGN	AMS	11/20/12	SCALE	N/A REV. 0
CADD	AMS	11/20/12		
CHECK	SCA	11/20/12		4-1
REVIEW	RRJ	11/20/12		

APPENDIX A

FLOW AND TRANSPORT MODELING DATA

Date	11/29/2012
By	AMS
Rev.	0

Appendix A: Flow and Transport Modeling Data[1]

		Base Case	Sensitivity Simulations														Steady-State Equivalent	
			Gradient		Porosity		Injection Rate		Transmissivity		Leakage		Storage		Conservative			
Input Parameter	Units	Best Estimate	Max	Min	Max	Min	1,000 GPM	1,500 GPM	Max	Min	Max	Min	Max	Min	Trace	Pressure		Source
Inyan Kara Water-Bearing Formation Hydraulic Properties																		
Regional Hydraulic Gradient, dh/dl	ft/ft	3.03E-04	7.89E-04	2.00E-04	3.03E-04	3.03E-04	3.03E-04	3.03E-04	3.03E-04	3.03E-04	3.03E-04	3.03E-04	3.03E-04	3.03E-04	7.89E-04	2.00E-04	3.03E-04	Whitehead, 1996
Direction of Regional Gradient, θ	degrees	N30°E	N30°E	N30°E	N30°E	N30°E	N30°E	N30°E	N30°E	N30°E	N30°E	N30°E	N30°E	N30°E	N30°E	N30°E	N30°E	Whitehead, 1996
Transmissivity, T	ft^2/day	1,750	1,750	1,750	1,750	1,750	1,750	1,750	7,000	400	1,750	1,750	1,750	1,750	7,000	400	1,750	Butler, 1984; Case, 1984; Milly, 1978; Neuzil, 1980; Konikow, 1976
Storage Coefficient, S	-	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.60E-03	1.00E-06	1.60E-03	1.00E-06	1.00E-05	Case, 1984; Milly, 1978; Neuzil, 1980
Leakage Factor, 1/B	1/ft	2.56E-07	2.56E-07	2.56E-07	2.56E-07	2.56E-07	2.56E-07	2.56E-07	1.28E-07	5.35E-07	1.09E-05	3.13E-08	2.56E-07	2.56E-07	5.43E-06	6.55E-08	2.56E-07	Hantush & Jacob, 1955 [2]
Porosity, n	-	0.3	0.3	0.3	0.385	0.042	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.042	0.385	0.3	NDIC O&G Well Files
Thickness, b	ft	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	NDIC O&G Well Files [3]
Hydraulic Conductivity, k	ft/day	5	5	5	5	5	5	5	20	1.143	5.000	5.000	5.000	5.000	20	1.143	5	Case, 1984; Milly, 1978; Neuzil, 1980
	cm/s	1.76E-03	1.76E-03	1.76E-03	1.76E-03	1.76E-03	1.76E-03	1.76E-03	7.06E-03	4.03E-04	1.76E-03	1.76E-03	1.76E-03	1.76E-03	7.06E-03	4.03E-04	1.76E-03	Case, 1984; Milly, 1978; Neuzil, 1980
Pre-Injection Head at Well	ft	1,808	1,808	1,808	1,808	1,808	1,808	1,808	1,808	1,808	1,808	1,808	1,808	1,808	1,808	1,808	1,808	
Cretaceous Confining Unit Hydraulic Properties																		
Hydraulic Conductivity, K'	ft/day	2.83E-07	2.83E-07	2.83E-07	2.83E-07	2.83E-07	2.83E-07	2.83E-07	2.83E-07	2.83E-07	5.10E-04	4.25E-09	2.83E-07	2.83E-07	5.10E-04	4.25E-09	2.83E-07	Downey, 1986
Thickness, b'	ft	2,475	2,475	2,475	2,475	2,475	2,475	2,475	2,475	2,475	2,475	2,475	2,475	2,475	2,475	2,475	2,475	NDIC O&G Well Files [3]
Well Properties																		
Casing Inner Diameter, D_c	ft	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	Preliminary Well Design [4]
Diameter of Drilled Hole, D_h	ft	0.729	0.729	0.729	0.729	0.729	0.729	0.729	0.729	0.729	0.729	0.729	0.729	0.729	0.729	0.729	0.729	Preliminary Well Design [4]
Screen Length, L_s	ft	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	Preliminary Well Design [4]
Screen Top Depth, d_{st}	ft	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	Preliminary Well Design [4]
Injection Rate, Q	gpm	-500	-500	-500	-500	-500	-1,000	-1,500	-500	-500	-500	-500	-500	-500	-500	-500	-500	Preliminary Well Design [4]
Duration of Injection																		
Time	yrs	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	5,000	Preliminary Well Design [4]
Results																		
Max Pressure Increase at Well	ft	141	141	141	141	141	282	422	37	588	113	142	119	146	30	635	146	AquiferWin32 Output
	psi	61	61	61	61	61	122	183	16	255	49	62	52	63	13	275	63	AquiferWin32 Output
Post-Injection Head at Well	ft	1,949	1,949	1,949	1,949	1,949	2,090	2,230	1,845	2,396	1,921	1,950	1,927	1,954	1,838	2,443	1,954	
Radial Extent of 50 Foot Pressure Increase	miles	1.5	1.5	1.5	1.5	1.5	26	69	-	61	<0.1	1.7	0.13	2.7	-	209	2.7	AquiferWin32 Output
Max Distance Particle Travels After 50 Years of Injection	miles	0.42	0.44	0.42	0.37	1.3	0.63	0.77	0.46	0.42	0.42	0.42	0.42	0.42	2.15	0.37	5.6	AquiferWin32 Output

[1] Modeling was completed using Hantush and Jacob (1955) Leaky Aquifer Transient Solution in AquiferWin32. Refer to GRE's underground injection permit application for additional modeling discussion and details.

[2] Hantush method for calculating leakage through overlying confining unit

[3] RockWorks 2004 was used to model isopachs from NDIC Oil & Gas well formation records

[4] Well design by Golder Associates Inc.

* Yellow highlighted cells represent properties that changed from the Base Case Simulation, green highlighted cells are calculated values that changed due to changes to yellow highlighted cells

Golder Associates

APPENDIX B

EPA UNDERGROUND INJECTION CONTROL GUIDANCE 34, ATTACHMENT 3

Attachment 3

GUIDELINES FOR REVIEWING

AQUIFER EXEMPTION REQUESTS

BACKGROUND

The Consolidated Permits Regulations (40 CFR §§146.04 and 144.7) allow EPA, or approved State programs with Environmental Protection Agency (EPA) concurrence, to exempt underground sources of drinking water from protection under certain circumstances. An underground source of drinking water may be exempted if:

1. It does not currently serve as a source of drinking water and;

2. It cannot now and will not in the future serve as a source of drinking water because:

    (a) It is mineral, hydrocarbon, or geothermal energy producing, or it can be demonstrated by a permit applicant as a part of a permit application for a Class II or III operation to contain minerals or hydrocarbons that considering their quantity and location are expected to be commercially producible;

    (b) It is situated at a depth or location which makes recovery of water for drinking water purposes economically or technologically impractical;

    (c) It is so contaminated that it would be economically or technologically impractical to render that water fit for human consumption; or

    (d) It is located over a Class III well mining area subject to subsidence or catastrophic collapse; or

3. The Total Dissolved Solids content of the ground water is more than 3,000 and less than 10,000 mg/l and it is not reasonably expected to supply a public water system.

Regulations at 40 CFR §144.7(b)(1) state that "The Director may identify (by narrative description, illustrations, maps or other means) and describe in geographic and/or geometric terms (such as vertical and lateral limits and gradient) which are clear and definite all aquifers or parts thereof which the Director proposes to designate as exempted aquifers. . ." If an exemption is proposed under 40 CFR §146.4(b)(1), the applicant for a Class II or III injection well permit must submit information to demonstrate "commercial producibility." To demonstrate producibility the applicant for a Class III injection well permit may provide a map and general description of the mining zone, analysis of the amenability of the mining zone to the proposed mining method, and a production timetable. Applicants for an exemption for a Class II injection well may demonstrate producibility by providing information such as logs, core data, drill stem test information, a formation description, and oil data for the well in question or surrounding wells.

Except as listed above, the regulations do not specify technical criteria for the EPA to judge aquifer exemption requests. The EPA therefore developed the following technical criteria. These criteria include general information requirements common to all aquifer exemption requests. These are followed by specific criteria to evaluate each type of exemption request listed above.

EPA will approve aquifer exemptions for only specific purposes. All exemption request approvals will include a description of injection activities allowed and a statement that additional approvals would be needed for other injection activities (e.g., hazardous waste disposal into an aquifer exempted for mineral production).

EVALUATION CRITERIA

General

Applicants requesting exemptions must provide the following general information:

1. A topographic map of the proposed exempted area. The map must show the boundaries of the area to be exempted. Any map which precisely delineates the proposed exempted area is acceptable.

2. A written description of the proposed exempted aquifer including:

    (a) Name of formation of aquifer.

    (b) Subsurface depth or elevation of zone.

    (c) Vertical confinement from other underground sources of drinking water.

    (d) Thickness of proposed exempted aquifer.

    (e) Area of exemption (e.g., acres, square miles, etc.).

    (f) A water quality analysis of the horizon to be exempted.

In addition to the above descriptive information concerning the aquifer, all exemption requests must demonstrate that the aquifer ". . . does not currently serve as a source of drinking water." (40 CFR §146.4(a)). To demonstrate this, the applicant should survey the proposed exempted area to identify any water supply wells which tap the proposed exempted aquifer. The area to be surveyed should cover the exempted zone and a buffer zone outside the exempted area. The buffer zone should extend a minimum of a 1/4 mile from the boundary of the exempted area. Any water supply wells located should be identified on the map showing the proposed exempted area.

If no water supply wells would be affected by the exemption, the request should state that a survey was conducted and no water supply wells are located which tap the aquifer to be exempted within the proposed area. If the exemption pertains to only a portion of an aquifer, a demonstration must be made that the waste will remain in the exempted portion. Such a demonstration should consider among other factors, the pressure in the injection zone, the waste volume, injected waste characteristics (i.e., specific gravity, persistence, etc.) in the life of the facility.

Specific Information

§146.4(b)(1) It cannot now and will not in the future serve as a source of drinking water because: it is mineral, hydrocarbon, or geothermal energy producing or can be demonstrated by a permit applicant as part of a permit application for a Class II or III operation to contain minerals or hydrocarbons that considering their quantity and location are expected to be commercially producible.

If the proposed exemption is to allow a Class II enhanced oil recovery well or an existing Class III injection well operation to continue, the fact that it has a history of hydrocarbon or mineral production will be sufficient proof that this standard is met. Many times it may be necessary to slightly expand an existing well field to recover minerals or hydrocarbons. In this case, the applicant must show only that the exemption request is for expanding the previously exempted aquifer and state his reasons for believing that there are commercially producible quantities of minerals within the expanded area.

Applicants for aquifer exemptions to allow new in-situ mining must demonstrate that the aquifer is expected to contain commercially producible quantities of minerals. Information to be provided may include: a summary of logging which indicates that commercially producible quantities of minerals are present, a description of the mining method to be used, general information on the mineralogy and geochemistry of the mining zone, and a development timetable. The applicant may also identify nearby projects which produce from the formation proposed for exemption. Many Class III injection well permit applicants may consider much information concerning production potential to be proprietary. As a matter of policy, some States do not allow any information submitted as part of a permit application to be confidential. In those cases where potential production information is not being submitted, it may be necessary for EPA to participate with the State in discussions with the applicant to obtain sufficient evidence to indicate that the ore zone is commercially producible. The information to be discussed would include the results of any R & D pilot project.

Exemptions relating to any new Class II wells which will be injecting into a producing or previously produced horizon should include the following types of information.

a. Production history of the well if it is a former production well which is being converted.

b. Description of any drill stem tests run on the horizon in question. This should include information on the amount of oil and water produced during the test.

c. Production history of other wells in the vicinity which produce from the horizon in question.

d. Description of the project, if it is an enhanced recovery operation including the number of wells and there location.

<u>§146.4(b)(2) It cannot now and will not in the future serve as a source of drinking water because: It is situated at a depth or location which makes recovery of water for drinking water purposes economically or technologically impractical:</u>

EPA consideration of an aquifer exemption request under this provision would turn on: The availability of alternative supplies, the adequacy of alternatives to meet present and future needs, and a demonstration that there are major costs for treatment and or development associated with the use of the aquifer.

The economic evaluation, submitted by the applicant, should consider the above factors, and these that follow:

1. Distance from the proposed exempted aquifer to public water supplies.

2. Current sources of water supply for potential users of the proposed exempted aquifer.

3. Availability and quality of alternative water supply sources.

4. Analysis of future water supply needs within the general area.

5. Depth of proposed exempted aquifer.

6. Quality of the water in the proposed exempted aquifer.

Costs to develop the proposed exempted aquifer as a water supply source including any treatment costs and costs to develop alternative water supplies. This should include costs for well construction, transportation, and water treatment for each source.

<u>§146.4(b)(3) It cannot now and will not in the future serve source of drinking water because: It is so contaminated that it would be economically or technologically impractical to render that water fit for human consumption.</u>

Economic considerations would also weigh heavily in EPA's decision on aquifer exemption requests under this section. Unlike the previous section, the economics involved are controlled by the cost of technology to render water fit for human consumption. Treatment methods can usually be found to render water potable. However, costs of that treatment may often be prohibitive either in absolute terms or compared to the cost to develop alternative water supplies.

EPA's evaluation of aquifer exemption requests under this section will consider the following information submitted by the applicant:

(a) concentrations and types of contaminants in the aquifer.

(b) source of contamination.

(c) whether contamination source has been abated.

(d) extent of contaminated area.

(e) probability that the contaminant plume will pass the through proposed exempted area.

(f) ability of treatment to remove contaminants from ground water.

(g) chemical content of proposed injected fluids.

(h) current water supply in the area.

(i) alternative water supplies.

(j) costs to develop current and probable future water supplies, cost to develop water supply from proposed exempted aquifer. This should include well construction costs, transportation costs, water treatment costs, etc.

(k) projections on future use of the proposed aquifer.

<u>§146.4(b)(4) It cannot now and will not in the future serve as a source of drinking water because: It is located over a Class III mining area subject to subsidence or catastrophic collapse:</u>

An aquifer exemption request under this section should discuss the proposed mining method and why that method necessarily causes subsidence or catastrophic collapse. The possibility that non-exempted underground sources of drinking would be contaminated due to the collapse should also be addressed in the application.

<u>§146.4(c) The Total Dissolved Solids content of the ground water is more than 3,000 and less than 10,000 mg/l and it is not reasonably expected to supply a public water system.</u>

An application under this provision must include information about the quality and availability of water from the aquifer proposed for exemption. Also, the exemption request must analyze the potential for public water supply use of the aquifer. This may include: a description of current sources of public water supply in the area, a discussion of the adequacy of current water supply sources to supply future needs, population projections, economy, future technology, and a discussion of other available water supply sources within the area.

APPENDIX C

ECONOMIC EVALUATION SUPPORTING MATERIAL

Table C-1: Well Pumps Capital Cost

Item	Value		Unit
	Washburn	Underwood	
Cost of Pump	$15,000	$6,400	-
Design Flow Rate	500	200	gpm
Design Head	427	372	ft
Number of Pumps Required	1	1	-
Cost of Miscellaneous Infrastructure	$25,000	$25,000	-
Total Cost of Pumps	$40,000	$31,400	-

Note:

Pump cost is based on quote provided by Quadna. Other values are Golder estimates.

Table C-2: Pipeline Capital Cost

Item	Value		Unit
	Washburn	Underwood	
Pipeline Unit Cost	$71	$72	$/ft
Length of Pipeline	44,352	32,736	ft
Cost of Pipeline	$3,163,085	$2,343,364	-

Note:

All values are Golder estimates. Backup for the pipeline unit cost is provided in Tables C-8 and C-9.

Table C-3: Well Capital Costs

Washburn Well (12" production casing)							
ITEM	**(ft)**	**($/day)**	**Days**	**TANGIBLE**	**INTANGIBLE**		**TOTAL**
Water Well Installation (Boart Longyear Quote)				$1,498,528			$1,498,528
Drilling Support							
Miscellaneous Supplies					$15,000		$15,000
Trash Hauling/Sanitation		$100	20		$2,000		$2,000
Potable Water		$30	20		$600		$600
Communications		$500	20		$10,000		$10,000
Mudlogging/Wellsite Geologist		$1,000	10		$10,000		$10,000
Open Hole Logging					$25,000		$25,000
Coring/DSTs (Labor and equipment)							$0
Wellsite Supervision		$1,650	20		$33,000		$33,000
Engineering Support					$0		$0
Plug and Abandon							$0
Miscellaneous & Contingencies (5%)					$79,706		$79,706
TOTAL WELL COSTS				**$1,498,528**	**$175,306**		**$1,673,834**

Notes:
Water well installation cost is based on a quote provided by Boart Longyear. Drilling support costs are based on estimates developed as part of GRE's Underground Injection Well project.

Underwood Well (7" production casing)							
ITEM	**(ft)**	**($/day)**	**Days**	**TANGIBLE**	**INTANGIBLE**		**TOTAL**
DRILLING (20 Days)							
Drilling Overhead					$0		$0
Legal, Abstracts and Title Opinions					$0		$0
Insurance							$0
Location Preparation					$25,000		$25,000
Contract Labor (BHA testing, csg head, etc)					$4,000		$4,000
Temporary Equipment (Fences, Culverts, etc)					$0		$0
Rig mobilization and de-mobilization					$200,000		$200,000
Drilling Rig Dayrate		$20,000	20		$400,000		$400,000
Drilling Rig Fuel		$3,600	15		$54,000		$54,000
Surface Casing	1,200	$28			$33,600		$33,600
Casing Head and Fittings					$5,000		$5,000
Intermediate Casing					$0		$0
Cement & Float Equipment					$24,000		$24,000
Casing Crew					$2,500		$2,500
Production Casing	5,300	$20		$106,000			$106,000
Cement & Float Equipment					$50,000		$50,000
Casing Crew					$30,000		$30,000
Casing Head and Fittings				$30,000			$30,000
Tubing Head Labor					$5,000		$0
Drilling Mud Hauling					$0		$0
Transportation		$1,000	20		$20,000		$20,000
Mud and Chemicals, etc.					$50,000		$50,000
Reclamation: Dirtwork and Mud Disposal					$4,000		$4,000
Surface Equipment Rentals (Camp,solids equip,etc)		$1,000	20		$20,000		$20,000
Drill String Rentals - Down hole rentals					$20,000		$20,000
Bits					$20,000		$20,000
Directional Drilling Tools					$0		$0
Directional Drilling Labor					$0		$0

Table C-3: Well Capital Costs

Underwood Well (7" production casing) - cont'd							
ITEM	**(ft)**	**($/day)**	**Days**	**TANGIBLE**	**INTANGIBLE**		**TOTAL**
Drilling Support							
Miscellaneous Supplies					$15,000		$15,000
Trash Hauling/Sanitation		$100	20		$2,000		$2,000
Potable Water		$30	20		$600		$600
Communications		$500	20		$10,000		$10,000
Mudlogging/Wellsite Geologist		$1,000	10		$10,000		$10,000
Open Hole Logging					$25,000		$25,000
Coring/DSTs (Labor and equipment)							$0
Wellsite Supervision		$1,650	20		$33,000		$33,000
Engineering Support					$0		$0
Plug and Abandon							$0
Miscellaneous & Contingencies (5%)					$53,135		$53,135
TOTAL WELL COSTS				**$136,000**	**$1,115,835**		**$1,246,835**

Note:

Underwood well costs are based on estimates developed as part of GRE's Underground Injection Well project.

Golder Associates

Table C-4: Water Treatment Facility Capital Costs

Washburn Facility

Item	**Qty**	**UOM**	**Unit $**	**Extended**
Equipment Cost (Installed)				
Pretreatment filters 500 gpm	1	each	$324,000	$324,000
RO System 500 gpm	1	each	$432,000	$432,000
Hypochlorite disinfection system	1	each	$11,000	$11,000
Finished Water Storage 500,000 gal	1	each	$540,000	$540,000
10 acre brine evaporation pond	1	each	$648,000	$648,000
Electrical service	1	each	$300,000	$300,000
Control system	1	each	$100,000	$100,000
Total Direct Equipment				$2,355,000
Installation/Facility Cost				
Building	1,800	ft^2	$150	$270,000
Site work	0.08	acre	$100,000	$8,264
Building foundations	60	cy	$400	$24,090
Equipment installation	40	%	$2,355,000	$942,000
Equipment freight	2	%	$2,355,000	$47,100
Commissioning	1	ls	$0	$0
Total Installation Cost				$1,291,455
Total Capital Cost				
Total Direct Cost				$3,646,455
Indirect Costs				
Contingency	30	%	$3,646,455	$1,093,936
GC Indirect Cost	15	%	$4,740,391	$711,059
Total Construction Cost				$5,451,450
Design	8	%	$5,451,450	$436,116
Construction Management	6	%	$5,451,450	$327,087
Total Capital Cost				**$6,214,653**

Note:
All values are Golder estimates and are based on the Dakota aquifer water chemistry described in Section 2.1.3.

Table C-4: Water Treatment Facility Capital Costs

Underwood Facility

Item	Qty	UOM	Unit $	Extended
Equipment Cost (Installed)				
Pretreatment filters 200 gpm	1	each	$171,000	$171,000
RO System 200 gpm	1	each	$227,000	$227,000
Hypochlorite disinfection system	1	each	$6,000	$6,000
Finished Water Storage 200,000 gal	1	each	$284,000	$284,000
5 acre brine evaporation pond	1	each	$341,000	$341,000
electrical service	1	each	$200,000	$200,000
Control system	1	each	$100,000	$100,000
Total Direct Equipment				$1,329,000
Installation/Facility Cost				
Building	1,250	ft^2	$150	$187,500
Site work	0.06	acre	$100,000	$5,739
Building foundations	60	cy	$400	$24,090
Equipment installation	40	%	$1,329,000	$531,600
Equipment freight	2	%	$1,329,000	$26,580
Commissioning	1	ls	$0	$0
Total Installation Cost				$775,510
Total Capital Cost				
Total Direct Cost				$2,104,510
Indirect Costs				
Contingency	30	%	$2,104,510	$631,353
GC Indirect Cost	15	%	$2,735,862	$410,379
Total Construction Cost				$3,146,242
Design	8	%	$3,146,242	$251,699
Construction Management	6	%	$3,146,242	$188,775
Total Capital Cost				**$3,586,716**

Note:
All values are Golder estimates and are based on the Dakota aquifer water chemistry described in Section 2.1.3.

Table C-5: Well Pumps Annual Operations and Maintenance Costs

Item	Value		Unit
	Washburn	Underwood	
Design Flow	141	59	gpm
Design Head	427	372	ft
Efficiency	75%	75%	%
Brake Horsepower	20	7	hp
Motor Efficiency	90%	90%	%
Electric Horsepower	22	8	hp
Conversion Factor	0.75	0.75	kW/hp
Required Energy	17	6	kWh
Cost of Energy	$0.07	$0.07	$/kWh
Annual Cost per Pump	$10,339	$3,778	-
Number of Pumps	1	1	-
Annual Power Cost	$10,339	$3,778	-
Annual Maintenance rate	$5,000	$5,000	-
Total Annual Cost	$15,339	$8,778	-

Note:
Design flows are based on data provided by the towns. Other values are Golder estimates.

Table C-6: Water Treatment O&M Costs

Washburn Facility

Volumes Treated					
Average flow	141	gpm			
Duration	52	weeks/year			
Annual average flow		gals/year			73,906,560
Total Annual Flow					73,906,560
Labor Cost					
Lead Operators	1	FTE			
OT/Callouts	20%	%			
Operations hours	2,496	hours/year			
Operations Labor Cost	$35	/hour			$ 87,360
Assistant Operators	1.5	FTE			
OT/Callouts	20%	%			
Operations hours	3,744	hours/year			
Operations Labor Cost	$25	/hour			$ 93,600
Maintenance Technicians	0.75	FTE			
OT/Callouts	20%	%			
Maintenance hours	1,872	hours/year			
Maintenance Labor Cost	$35	/hour			$ 65,520
Operations Supervisor	0.20	FTE	$70,000	$/year	$ 14,000
ES&H Supervisor	0.20	FTE	$65,000	$/year	$ 13,000
Maintenance Supervisor	0.20	FTE	$65,000	$/year	$ 13,000
Administrative Support	0.20	FTE	$65,000	$/year	$ 13,000
Engineering Support	0.00	FTE	$65,000	$/year	$ -
Compliance Support	0.20	FTE	$70,000	$/year	$ 14,000
Total Labor Cost					$ 313,480
Utilities Cost					
On-line factor	90	%			
Motor efficiency factor	75	%			
Connected load, average	75	HP			
Duration	52	weeks			
Power cost	329,926	kw-hr	$0.07	$/kw-hr	$ 23,095
Gas consumption, average	0	BTU/hr			
Gas cost	0	therms/year	$0.60	$/therm	$ -
Water	$0.00	allowance/year			$ -
Sewer	$0.00	allowance/year			$ -
Total Utility Cost					$ 23,095
Chemical Cost					
Antiscalant	10.00	mg/l			
	6,162	pounds/year			
	$2.00	$/pound			$ 12,323
Biocide	5.00	mg/l			
	3,081	pounds/year			
	$2.00	$/pound			$ 6,162
RO membrane cleaner	0.00				
	275,000	gallons/year			
	$0.02	$/gallon			$ 5,500
Sodium hypochlorite	10.00	mg/l			
	6,162	pounds/year			
	$0.18	$/pound			$ 1,109
Total Chemical Cost					$ 25,094
Miscellaneous Cost					
Sampling and analysis					
Sampling supplies	$10,400.00	allowance		$ 10,400.00	
Environmental samples	26	samples/year			
Sample analysis	$50.00	$/sample		$ 1,300.00	
Sample shipping	$0.00	$/sample		$ -	
Miscellaneous Cost	$5,200.00	allowance		$ 5,200.00	$ 16,900
Maintenance	$2,355,000	Total direct equipment cost			
	1.50%	Routine maintenance		$ 35,325.00	
	0.00%	Capital replacement		$ -	$ 35,325
Administrative materials	$0.00	allowance/year			$ -
Total Miscellaneous Cost					$ 52,225
Total O&M Cost					$ 413,894

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Table C-6: Water Treatment O&M Costs

Underwood Facility

Volumes Treated					
Average flow	59	gpm			
Duration	52	weeks/year			
Annual average flow		gals/year			30,925,440
Total Annual Flow					30,925,440
Labor Cost					
Lead Operators	1	FTE			
OT/Callouts	20%	%			
Operations hours	2,496	hours/year			
Operations Labor Cost	$35	/hour			$ 87,360
Assistant Operators	1.5	FTE			
OT/Callouts	20%	%			
Operations hours	3,744	hours/year			
Operations Labor Cost	$25	/hour			$ 93,600
Maintenance Technicians	0.5	FTE			
OT/Callouts	20%	%			
Maintenance hours	1,248	hours/year			
Maintenance Labor Cost	$35	/hour			$ 43,680
Operations Supervisor	0.10	FTE	$70,000	$/year	$ 7,000
ES&H Supervisor	0.10	FTE	$65,000	$/year	$ 6,500
Maintenance Supervisor	0.10	FTE	$65,000	$/year	$ 6,500
Administrative Support	0.10	FTE	$65,000	$/year	$ 6,500
Engineering Support	0.00	FTE	$65,000	$/year	$ -
Compliance Support	0.20	FTE	$70,000	$/year	$ 14,000
Total Labor Cost					$ 265,140
Utilities Cost					
On-line factor	90	%			
Motor efficiency factor	75	%			
Connected load, average	50	HP			
Duration	52	weeks			
Power cost	219,951	kw-hr	$0.07	$/kw-hr	$ 15,397
Gas consumption, average	0	BTU/hr			
Gas cost	0	therms/year	$0.60	$/therm	$ -
Water	$0.00	allowance/year			$ -
Sewer	$0.00	allowance/year			$ -
Total Utility Cost					$ 15,397
Chemical Cost					
Antiscalant	10.00	mg/l			
	2,578	pounds/year			
	$2.00	$/pound			$ 5,157
Biocide	5.00	mg/l			
	1,289	pounds/year			
	$2.00	$/pound			$ 2,578
RO membrane cleaner	0.00				
	275,000	gallons/year			
	$0.02	$/gallon			$ 5,500
Sodium hypochlorite	10.00	mg/l			
	2,578	pounds/year			
	$0.18	$/pound			$ 464
Total Chemical Cost					$ 13,699
Miscellaneous Cost					
Sampling and analysis					
Sampling supplies	$10,400.00	allowance		$ 10,400.00	
Environmental samples	26	samples/year			
Sample analysis	$50.00	$/sample		$ 1,300.00	
Sample shipping	$0.00	$/sample		$ -	
Miscellaneous Cost	$5,200.00	allowance		$ 5,200.00	$ 16,900
Maintenance	$1,329,000	Total direct equipment cost			
	1.50%	Routine maintenance		$ 19,935.00	
	0.00%	Capital replacement		$ -	$ 19,935
Administrative materials	$0.00	allowance/year			$ -
Total Miscellaneous Cost					$ 36,835
Total O&M Cost					**$ 331,070**

Note:
All values are Golder estimates and are based on the Dakota aquifer water chemistry described in Section 2.1.3.

Table C-7: Monthly Payments Associated with Capital Costs

Item	Value	
	Washburn	**Underwood**
Total Cost	$11,242,000	$7,358,000
Downpayment	$0	$0
Item Initial Balance	$11,242,000	$7,358,000
Annual Percentage Rate	5.00%	5.00%
Monthly Percentage Rate	0.42%	0.42%
Initial Bond Date	6/1/2013	6/1/2013
Bond Maturity Date	6/1/2023	6/1/2023
Total Number of Payments	120	120
Initial Monthly Payment Required	$119,239	$78,043
Total Cost	$14,308,662	$9,365,161
Required Annual Cost	**$1,430,866**	**$936,516**

Note:
All values are Golder estimates.

Table C-8: Pipeline Estimate - Underwood

DESCRIPTION	QUANTITY (Units)		Material		Labor		Equipment		Equip Maint		ST&S		Total	
Unload & Stage Pipe	130	HR			$45,923		$19,370		$1,170		$0		**$66,463**	
					$353.25	/HR	$149.00	/HR	$9.00	/HR	$0.00	/HR	$511.25	/HR
Lay Pipe	690	HR			$242,225		$202,860		$28,635		$3,450		**$477,170**	
					$351.05	/HR	$294.00	/HR	$41.50	/HR	$5.00	/HR	$691.55	/HR
PVC Pipe (8")	27,480	LF	$416,322		$0		$0		$0		$0		**$416,322**	
			$15.15	/LF		/LF		/LF		/LF		/LF	$15	/LF
PVC 45 Degree Elbows (8")	8	EA	$492		$0		$0		$0		$0		**$492**	
			$61.54	/EA		/EA		/EA		/EA		/EA	$62	/EA
Backfill	42,137	TONS	$505,642		$0		$0		$0		$0		**$505,642**	
			$12.00	/TONS		/TONS		/TONS		/TONS		/TONS	$12	/TONS
Gravel (Base)	1,525	CY	$45,760		$0		$0		$0		$0		**$45,760**	
			$30.00	/CY		/CY		/CY		/CY		/CY	$30	/CY
	Totals		$968,216		$288,147		$222,230		$29,805		$3,450		**$1,511,848**	
	Cost per Unit		$968,216	/LS	$288,147	/LS	$222,230	/LS	$29,805	/LS	$3,450	/LS	**$1,511,848**	/LS
											With 30% Overhead		$1,965,402	/LS
											Unit Cost		$72	/LF

Table C-9: Pipeline Estimate - Washburn

DESCRIPTION	QUANTITY (Units)		Material		Labor		Equipment		Equip Maint		ST&S		Total	
Unload & Stage Pipe	200	HR			$70,650		$29,800		$1,800		$0		**$102,250**	
					$353.25	/HR	$149.00	/HR	$9.00	/HR	$0.00	/HR	$511.25	/HR
Lay Pipe	1,110	HR			$389,666		$326,340		$46,065		$5,550		**$767,621**	
					$351.05	/HR	$294.00	/HR	$41.50	/HR	$5.00	/HR	$691.55	/HR
PVC Pipe (8")	44,360	LF	$672,054		$0		$0		$0		$0		**$672,054**	
			$15.15	/LF		/LF		/LF		/LF		/LF	$15	/LF
PVC 45 Degree Elbows (8")	8	EA	$492		$0		$0		$0		$0		**$492**	
			$61.54	/EA		/EA		/EA		/EA		/EA	$62	/EA
Backfill	68,067	TONS	$816,806		$0		$0		$0		$0		**$816,806**	
			$12.00	/TONS		/TONS		/TONS		/TONS		/TONS	$12	/TONS
Gravel (Base)	2,464	CY	$73,920		$0		$0		$0		$0		**$73,920**	
			$30.00	/CY		/CY		/CY		/CY		/CY	$30	/CY
	Totals		$1,563,272		$460,316		$356,140		$47,865		$5,550		**$2,433,143**	
	Cost per Unit		$1,563,272	/LS	$460,316	/LS	$356,140	/LS	$47,865	/LS	$5,550	/LS	**$2,433,143**	/LS
											With 30% Overheads		$3,163,085	/LS
											Unit Price		$71	/LF

BOART LONGYEAR

BOART LONGYEAR	Proposal for Drilling Services
Salt Lake City Rotary Zone 2745 West California Ave Salt Lake City, Utah 84104 Phone: 801-973-6667 Fax: 801-973-4572 www.boartlongyear.com	*Client:* **Golder Associates** *Contact:* **Scott Allen** *Email:* Scott_Allen@golder.com *Address:* 44 Union Blvd, Suite 300 Lakewood, CO 80228 *Phone:* (303) 980-0540

3900' Water Well

Item	Description	Unit	Unit Price	Qty	Total Price
1	Mobilization and Set Up Drill Site	Lump	$92,500.00	1	$92,500.00
2	Drill 31" Hole from Surface to 40'. Furnish and Install 26" Casing to 40'. Cement Casing in Place	Foot	$649.00	40	$25,960.00
3	Wait on Cement	Hour	$670.00	6	$4,020.00
4	Drill 24" Hole from 40' to 1200'	Foot	$240.00	1160	$278,400.00
5	Furnish and Install 20" (.375" Wall) LCS Welded Casing from Surface to 1200'	Foot	$110.00	1200	$132,000.00
6	Cement Casing in Place (120% of hole volume).	Cu Ft	$45.00	1383	$62,235.00
7	Wait on Cement	Hour	$670.00	6	$4,020.00
8	Drill 17.5" Hole from 1200' to 3900'	Foot	$133.00	2700	$359,100.00
9	Furnish and Install 12.75" OD LCS Slotted Pipe	Foot	$79.00	350	$27,650.00
10	Furnish and Install 12.75" OD LCS Blank Pipe	Foot	$66.00	3550	$234,300.00
11	Furnish and Install Gravel Pack (120% of hole volume)	Cu Ft	$39.00	332	$12,948.00
12	Furnish and Install Transitiion Sand and Hole Plug	Cu Ft	$35.00	10	$350.00
13	Furnish and Install Cement to Surface (120% of Hole Volume)	Cu Ft	$45.00	2797	$125,865.00
14	Wait on Cement	Hour	$670.00	12	$8,040.00
15	Develop Well with Surge Block and Dual Wall Pipe	Hour	$805.00	48	$38,640.00
16	Clean Up Drill Site and Demobilize	Lump	$92,500.00	1	$92,500.00
				Estimated Total (Taxes not Included)---->	**$1,498,528.00**

Scope of Work Summary:

Drill Production Well to 3900'. Case and Develop Well. Furnish and Install ESP for 500 gpm at 500' TDH

Equipment and Approach Summary:

Boart Longyear(BLY) will provide one drill rig and all support equipment necessary to perform all work. All fluids will be contained and circulated in above ground tanks. Drilling cuttings and fluids will be disposed of on site, or will be disposed of by Client.

Schedule and Crew:

Boart Longyear would work 24/7 with 2-12 hour shifts once onsite

2/19/2013

BOART LONGYEAR

Exclusions:

1 Access road to drilling location, drilling pad construction, site prep and restoration.
2 Handling of any hazardous materials if soil or cuttings are determined to be contaminated
3 Delays out of the control of the driller
4 Repair of damage to unmarked utilities
5 Unspecified obstruction drilling (i.e.: footings, foundations etc.)
6 Drilling water supply
7 Union or prevailing/Davis Bacon wages
8 Performance and payment bonds
9 Re-drilling of bore holes due to caving or collapsed formations
10 Any additional work not explicitly included in bid proposal
11 Traffic control measures
12 Noise Control (i.e.: sound panels or blankets)
13 Permits or licenses (i.e.: traffic control, encroachment, discharge, erosion control, etc.)
14 Sales tax or use taxes. (All applicable taxes will be added at time of invoicing)

Assumptions:

1 Work has been bid based upon the information provided to BLY with the following exclusions listed above. Work will be billed based upon the **actual quantities performed** in accordance with the above provided unit rates.

2 Client to provide a level drill pad and access, accompanied by nearby staging area for deliveries and material storage.

3 An adequate drilling water supply (Fire Hydrant Flow) will be provided at or near the drill site by the client at no expense to BLY.

4 BLY will not be responsible for quality of water provided.
5 All shift delays required for items such as insufficient access, water level measurements or client requested safety pauses, etc. will be charged at the standby hourly rate
6 All work is subject to BLY standard terms and conditions unless a separate project specific agreement is executed by both parties prior to mobilization

Thank you for requesting this proposal from Boart Longyear Company. We look forward to the opportunity to work with you on this project.

Jeremy Kuhn
Contract Manager- Salt Lake Rotary
2745 West California Ave
Salt Lak (385) 235-3855
Office- (801) 673-7636
Cell-
Jeremy.Kuhn@boartlongyear.com

From: Dennis B. Demers <ddemers@quadna.com>
Sent: Friday, February 15, 2013 4:02 PM
To: Allen, Scott
Subject: RE: Well Pump Budgetary Cost

Scott,

I just heard back from the factory, here are budgetary prices for the two pumps. These prices do not include the extended column pipe or the motor power cable, those are typically provided by the customer.

Washburn Pump: $15,000
Underwood Pump: $6,400

I hope this helps, please let me know if you need anything else.

Dennis Demers
Sales Engineer

Direct 303 215 4984 (forwards to mobile)
Mobile 303 325 6437
Main 303 430 0521
Fax 303 430 0851

Quadna
A DXP Company
14452 W. 44th Ave.
Golden, CO 80403
ddemers@dxpe.com

From: Allen, Scott [mailto:Scott_Allen@golder.com]
Sent: Thursday, February 14, 2013 5:12 PM
To: Dennis B. Demers
Subject: Re: Well Pump Budgetary Cost

Hi Dennis,

We had a change in design pressures for the well pump. The new values are:
- Washburn: 500 gpm at 185 psi
- Underwood: 200 gpm at 160 psi

Hopefully you can use these values in the quote.
Thank you for your help.
Scott

On Feb 13, 2013, at 8:28 AM, "Dennis B. Demers" <ddemers@quadna.com> wrote:

> Scott,
>
> It was nice speaking with you yesterday afternoon. I found the Goulds submersible deep well pump on their website this morning, I don't see a brochure to attach but here is a link to the VIS page where there are more details on construction and hydraulic performance. http://www.gouldspumps.com/Products/VIS/ I am hoping to find some brochures on this that I can bring along.

For our meeting this afternoon, I don't really have anything formal planned as far as a presentation; instead I'm planning on discussing this well pump application and then hopefully taking a few moments to introduce myself to some of the others. Here are a few people that have had fairly recent inquiries with Quadna, so they might be good contacts to start with.

Jessa Smith
Melissa Rhodes
Neal Gallagher
Christopher Beck

Please let me know if 2:00 PM still works for you. Thanks!

Dennis Demers
Sales Engineer

Direct 303 215 4984 (forwards to mobile)
Mobile 303 325 6437
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ddemers@dxpe.com

From: Lauren Martinez
Sent: Tuesday, February 12, 2013 11:11 AM
To: Dennis B. Demers
Subject: FW: Well Pump Budgetary Cost

From: Allen, Scott [mailto:Scott_Allen@golder.com]
Sent: Tuesday, February 12, 2013 11:09 AM
To: Lauren Martinez; Paul Hanson
Cc: Jorgenson, Ron
Subject: Well Pump Budgetary Cost

Hi Lauren and Paul,

Hope you both are well.

If you recall, you helped us last year with some preliminary information on underground injection pumps for our client in North Dakota. That project is ongoing with plans for procurement and construction this summer/fall, but right now we are responding to regulatory comments on our permits. I'd be happy to further explain the situation, but I was hoping you could help me with a budgetary cost for a water supply well pump. Attached is a conceptual schematic of our well. We are looking at a couple scenarios for casing diameter and flow so I was hoping to talk with you about typical well pumps.

Could you give me a call to discuss this?

Thank you,
Scott

Scott Allen, P.E. | Senior Project Engineer | **Golder Associates Inc.**
44 Union Boulevard, Suite 300, Lakewood, Colorado, USA 80228

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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